Surveys of Nesting Mid-continent Lesser Snow Geese and Ross's Geese in Eastern and Central Arctic Canada, 1997-98

R. H. Kerbes, K. M. Meeres, R. T. Alisauskas, F. D. Caswell, K. F. Abraham and R. K. Ross

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Surveys of Nesting Mid-continent Lesser Snow Geese and Ross's Geese in Eastern and Central Arctic Canada, 1997-98

Richard H. Kerbes[1], Katherine M. Meeres[1], Ray T. Alisauskas[1], F. Dale Caswell[2], Kenneth F. Abraham[3] and R. Kenyon Ross[4]

[1] Canadian Wildlife Service, 115 Perimeter Road, Saskatoon, Saskatchewan S7N 0X4, Canada
[2] Canadian Wildlife Service, 123 Main Street, Suite 150, Winnipeg, Manitoba R3C 4W2, Canada
[3] Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, Ontario K9J 8M5, Canada
[4] Canadian Wildlife Service, 49 Camelot Drive, Nepean, Ontario K1A 0H3, Canada

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115 Perimeter Road
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Ph: 306 975 5417
Fax: 306 975 4089
Email: kathy.macnearn@ec.gc.ca

Abstract

We estimated minimum numbers of nesting birds in the known colonies of the Mid-continent Population of Lesser Snow Geese (*Chen caerulescens caerulescens*) and Ross's Geese (*Chen rossii*), using aerial photography supplemented with ground surveys, in the Eastern Canadian Arctic in June 1997 and the Central Canadian Arctic in June 1998. We estimated 3,075,000 nesting Snow Geese in the Eastern Arctic (a 2.7-fold increase since the previous survey in 1979-80), and 740,600 nesting Snow Geese in the Central Arctic (a 7-fold increase since the survey in 1982). Thus, our minimum estimate for the Mid-continent Snow Goose Population in 1997-98 (Eastern + Central Arctic) was 3,815,600 nesting adults, which was an over 3-fold increase from the estimates for 1979-80 Eastern Arctic plus 1982 Central Arctic.

The number of known occupied colonies in the Eastern Arctic increased from 16 in 1979-80 to 26 in 1997. Most (56%) of the Eastern Arctic nesting Snow Geese were on Baffin Island, 24% on Southampton Island, 7% on West Hudson Bay, and 13% on South Hudson Bay. The respective regional proportions in 1979 were 40%, 21%, 28%, and 11%, showing that the proportion on West Hudson Bay has decreased to one quarter of its earlier value, while the proportions in the other three regions have increased.

Nesting Ross's Geese in 1997 totalled at least 542,800, with 519,300 in the Central Arctic (a 2.8-fold increase since 1988) and a minimum of 23,500 at McConnell River in the Eastern Arctic. Ross's Geese apparently initiated this colony in 1994. Their numbers appear to be increasing elsewhere in the Eastern Arctic.

We estimated that there were at least 1,260,000 Snow and Ross's geese nesting in the Central Arctic in 1998: 91% in the Queen Maud Gulf Migratory Bird Sanctuary area and the remainder in colonies on Jenny Lind Island, Adelaide Peninsula, and Rasmussen Basin. The estimated proportion of Ross's Geese among the Snow and Ross's geese nesting in the Queen Maud Gulf Migratory Bird Sanctuary area changed little, from 40% in 1988 to 43% in 1998. That area had 57 known occupied colonies in 1988 and 73 in 1998. In both years about 90% of the nesting birds were in the four largest colonies.

Results are discussed in relation to historical changes in numbers and distribution of nesting Mid-continent Snow Geese and Ross's Geese, photo surveys for monitoring population trends, and the recent and future use of periodic photo surveys for international management of these "overabundant" goose populations.

Résumé

Nous avons utilisé des photographies aériennes grand format et réalisé au sol des relevés de contrôle pour estimer les effectifs des oies nicheuses parmi les Petites Oies des neiges *(Chen caerulescens caerulenscens)* du milieu du continent et parmi les Oies de Ross (*Chen rossii*), cela dans les colonies connues de l'Arctique oriental canadien en juin 1997 et dans la région de l'Arctique central canadien en juin 1998. Nous avons estimé l'effectif de la Petite Oie blanche nicheuse en Arctique oriental à 3 075 000 (une augmentation presque triple depuis l'enquête précédente de 1979-80), et à 740 600 dans la région centrale de l'Arctique (une augmentation de sept fois depuis l'enquête de 1982). Ainsi, notre estimation minimale de la population de l'Oie blanche du milieu du continent en 1997-98 (incluant l'est et le centre de l'Arctique) était de 3 815 600 adultes nicheurs, représentant plus de trois fois les estimations de 1979-80 de l'Arctique oriental et celles de 1982 du centre de l'Arctique.

Le nombre de colonies connues et occupées en Arctique oriental est passé de 16 en 1979-80 à 26 en 1997. La plupart (56%) des Oies des neiges de l'Arctique oriental nichaient sur l'île de Baffin, 24% sur l'île Southampton, 7% à l'ouest de la baie d'Hudson, et 13% au sud de la baie d'Hudson. En 1979, les proportions régionales respectives étaient de 40%, 21%, 28% et 11%. C'est dire que la proportion à l'ouest de la Baie d'Hudson avait diminué d'un quart alors qu'ailleurs dans l'Arctique oriental, celle des trois autres régions avait augmentée.

En 1997, on dénombrait au moins 542 800 Oies de Ross nicheuses, soit 519 300 dans le centre de l'Arctique (une augmentation presque triple depuis 1988) et un minimum de 23 500 oies à la rivière McConnell en Arctique oriental. Il semble que des Oies de Ross ont inauguré cette colonie en 1994. Ailleurs dans l'Arctique oriental, leur nombre semble croître aussi.

En 1998, notre estimation des Oies des neiges et de Ross qui nichaient dans la région de l'Arctique central était d'au moins 1 260 000: 91% dans le refuge d'oiseaux migrateurs du golfe de la Reine-Maud et le reste dans les colonies de l'île Jenny Lind, de la péninsule Adelaide et du bassin Rasmussen. Le pourcentage d'Oies de Ross évalué parmi les Oies des neiges et de Ross nicheuses au refuge d'oiseaux migrateurs du golfe de la Reine-Maud, lui, a peu changé, ayant passé de 40% en 1988 à 43 % en 1998. En 1988, on a dénombré 57 colonies connues et occupées dans cette aire de nidification et 73 en 1998. Durant ces deux années, environ 90% des oies nicheuses se trouvaient dans les quatre plus grandes colonies.

Les résultats sont analysés selon les changements à long terme en rapport avec la quantité, la répartition des nids des Oies des neiges du milieu du continent et des Oies de Ross, les enquêtes photographiques pour surveiller la tendance démographique ainsi que l'utilisation d'enquêtes photographiques dans le but de gérer internationalement des populations d'oies 'surabondantes'.

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1. Introduction

Rapid growth over the past 30 years in the Mid-continent Population of Lesser Snow Geese (*Chen caerulescens caerulescens*), became a major concern for waterfowl managers in North America in the mid-1990s (Ankney 1996, Batt 1997). The breeding range of this population is spread over a very large part of northern Canada. For monitoring purposes, it can be subdivided into Eastern and Central Arctic subpopulations. Migrating through Ontario, Manitoba and Saskatchewan, this population winters mainly in the Mississippi and Central flyways, with small numbers of Snow Geese from the Central Arctic wintering in the Western Central Flyway (Fig. 1, Drewien et al 2003). Lesser Snow Geese share many of their nesting areas, particularly in the Central Arctic, with the closely related Ross's Goose (*Chen rossii*). As predicted by Prevett and MacInnes (1972), small but increasing numbers of Ross's Geese are nesting in Lesser Snow Goose colonies in the Eastern Arctic. Traditionally, most Ross's Geese (90%) wintered in the Pacific Flyway, but winter numbers have increased in the Central and Mississippi flyways (Fig. 1, Ryder and Alisauskas 1995, Kelley et al. 2001, Drewien et al 2003, Alisauskas et al. 2006). Numbers of both species, but especially Snow Geese, have increased to the point that their foraging activities have damaged coastal staging and nesting habitats, particularly in James Bay and southern and western Hudson Bay (Kerbes et al. 1990, Abraham and Jefferies 1997).

The Arctic Goose Habitat Working Group, under the Arctic Goose Joint Venture of the North American Waterfowl Management Plan, was formed by representatives of the Canadian Wildlife Service, the United States Fish and Wildlife Service and other wildlife agencies to address this continental conservation issue. The group's report (Batt 1997) recognized the complexity of the natural and human factors involved, and the need for information on the current status of the population. It recommended that high priority be given to obtaining an up-to-date estimate of the numbers and distribution of nesting birds in the Mid-continent Lesser Snow Goose Population and the associated Ross's Goose population. Accordingly, surveys of the nesting colonies were conducted in the Eastern Arctic in 1997 and in the Central Arctic in 1998.

Definitions and background:

Snow Geese or **Snows** refers to Lesser Snow Geese including both white and blue colour morphs.

Ross's Geese or **Ross's** are almost all white morph, but blue morph Ross's do exist, as do hybrids between white morph Ross's and blue morph Snows (McLandress and McLandress 1979). However, blue morph birds are exceedingly rare (less than 0.1%) (Ryder and Alisauskas 1995), and for analysis we considered the Ross's to have only a white morph.

Light geese includes all Lesser Snow and Ross's geese, regardless of colour morph.

The Eastern Arctic colonies (Fig. 2) extend over a very wide range of latitude, from James Bay (53° N) to Foxe Basin (68° N), a distance of 1,700 km. Kerbes (1975) conducted the first complete survey of the Eastern Arctic colonies in 1973, using aerial photography. He grouped

the colonies into four regions: Baffin Island, Southampton Island, West Hudson Bay, and South Hudson Bay. Ross's Geese, in small numbers, occur in each of those regions. Another air photo survey of the Eastern Arctic colonies was done in 1979-80 (Anghern 1979, Reed et al. 1987, Kerbes et al. 1990). Due mainly to the cost of covering such an extensive area, these colonies were not photographed again until 1997.

The Central Arctic light goose nesting range (Fig. 3) is less extensive than that of the Eastern Arctic, and consists primarily of the **Queen Maud Gulf Migratory Bird Sanctuary area (QMGMBS)**, Jenny Lind Island, and the Rasmussen Basin area. Considered to have been the nesting grounds for about 95% of the world's Ross's Geese, the Central Arctic also supports significant numbers of Mid-continent Lesser Snow Geese (Kerbes 1994, Alisauskas and Boyd 1994). Ryder (1969, 1971) was the first to survey the nesting colonies of light geese in the QMGMBS in 1965-67. He located colonies from a low-flying single-engine aircraft and visually estimated the total number of nesting birds and the percentage of Ross's Geese. That was a feasible method at that time, given the relatively small size and limited number of colonies. Kerbes (1994) used aerial photography combined with ground surveys to survey the Central Arctic colonies in 1976, 1982, and 1988. Alisauskas and Boyd (1994) did visual aerial surveys of some of the colonies in 1990-91.

The history of earlier field studies of Snow and Ross's geese on their Eastern and Central Arctic breeding grounds has been summarized by Cooch (1963), Ryder (1967), Kerbes (1975, 1994), and Cooke et al. (1995).

Objectives of the 1997-1998 surveys were to obtain estimates of the number and distribution of nesting Snow Geese in the Eastern and Central Arctic, and of nesting Ross's Geese in the Central Arctic and in the Eastern Arctic at McConnell River. We emphasize that these surveys focussed on one population component: the nesting adults in June. We did not attempt to estimate numbers of non-breeders, failed breeders, young of the year, nor total population size.

2. Methods

2.1. Obtaining air photos

Air photos of the nesting colonies were obtained in June, 1997 and 1998 (Table 1), approximately midway through the incubation period, using methods of previous photo surveys of the Snow and Ross's goose colonies in the Canadian Arctic (Kerbes 1975, 1986, 1994; Reed et al. 1987). Photography was done from a twin-engine aircraft equipped with a large format (23 x 23 cm) camera, 153 mm lens, and Kodak black and white film. Kodak Plus-X film was used to photograph the colonies from an altitude of 762 m above ground level, thereby providing a photo scale of 1:5,000, covering a strip of ground 1.15 km wide. Kodak Panatomic-X film was used from an aircraft at an altitude of 1,524 m, providing a 1:10,000 photo scale, and covering a strip 2.3 km wide. The Panatomic-X film has much finer image resolution than Plus-X, allowing a higher flying height and increased strip width, for more cost effective coverage. However, Panatomic-X needs clear skies for usable photos, whereas Plus-X can be used effectively, at least for counting white birds, under a variety of overcast conditions. The scale 1:5,000 and 1:10,000

photos obtained provided extensive systematic sample coverage, and in some cases complete coverage, of the nesting colonies from which counts of white morph Snow Geese and Ross's Geese were taken. Additional "low level" air photos using Plus-X from 305 m provided photo scale 1:2,000, for counts of blue morph Snow Geese and white morph Snow plus Ross's geese.

2.2. Analyzing Air Photos

Sample counts of nesting geese from all parts of a given colony were obtained by analyzing photos systematically selected from the photo coverage of the colony. Analyses of the total photo cover of many small colonies provided total counts for those colonies. White morph birds (or both white and blue morph birds from low level photos) were counted by examining the original film negatives in roll form on a light table with a binocular microscope. Counts of geese were made using a transparent grid of 0.5, 1.0 or 2.0 cm squares, depending on the density of geese and scale of film being analyzed, placed beneath the film. Birds were recorded as nesting birds (in pairs or singles on the ground) or as non-breeders (as "flyers" = all geese in flight, and as "flocks" = non-paired groupings of 5 or more birds on the ground). Our counts of non-breeders therefore included only those that were on or near the occupied nesting areas, and are not reported here. Significant numbers of non-breeders also occur in areas separate, and often distant, from the nesting areas. The estimate of percentage blue was determined from independent ground work, or from air photo counts of nesting birds and/or flying non-breeders. Colony boundaries were determined from the air photos by scanning and/or analyses to verify extent of area occupied by the nesting birds, supplemented in some cases by observations taken from the photo aircraft. Larger colonies were divided into strata based on nest densities.

The estimate of nesting geese on each colony was obtained by expanding the total count, or estimated total number of white morph birds, by the estimate of percentage blue morph of total geese. For colonies that were stratified according to density ranges, the number of white morph nesting birds was estimated for each stratum, and then for the whole colony. That total was then expanded by the percentage blue morph to estimate the total nesting birds, with 95% confidence limits, for the entire colony.

2.3 1997 Eastern Arctic

Three separate aircraft and crews obtained the aerial photographs: one covered Baffin and Southampton islands, a second covered West Hudson Bay and La Pérouse Bay, and a third covered the remainder of South Hudson Bay (Table 1). Analyses of all air photos were done by the Canadian Wildlife Service in Saskatoon, Saskatchewan.

Minimum number of Ross's Geese nesting within the Snow Goose colony at McConnell River was estimated by analyzing all of the north eastern part of the colony, which was known from ground surveys in previous years to have contained dense and obvious concentrations of nesting Ross's Geese. High density counts from the film (20 or more nesting birds per 100m X 100m grid square) were assumed to be entirely Ross's, and the total for those high density squares was

used as the minimum total Ross's within the McConnell River colony (see Section 4.1.3.1 below for more details).

2.4 1998 Central Arctic

In addition to aerial photography, ground work was done at selected colonies in the QMGMBS to estimate the species composition of the colonies, because images of white morph Snow and Ross's geese cannot be discriminated from each other on the photos.

Ground surveys were done by a helicopter-supported crew working from a camp at Karrak Lake (Colony 3). At colonies 2, 3, 9, 10, 18, 46, 68, 81 and 88, species and colour morph composition were determined by observers with binoculars counting numbers of live or dead Ross's, white morph Snow Geese, blue morph Snow Geese and Brant (*Branta bernicla*) at points chosen to representatively sample each colony. At each location, latitude and longitude were determined with Global Positioning System receivers. To sample mainland areas of colonies representatively, we used the following protocol. From where the helicopter landed, two to four observers walked at least 250 paces along paths (as constrained by any permanent water bodies) judged to maximize angles of travel between observers. After the initial sample nearest the helicopter, each observer continued to walk for about 500 paces away from the helicopter (again, as constrained by permanent water bodies). On islands with the longest axis <~300 metres, only one sample of species/color composition was taken; on islands ~300 to ~500 metres, >1 sample was taken. On larger islands, the protocol for mainland sampling was used except that the minimum distance between sample points was 250 metres.

Search for potential "new" nesting colonies in the QMGMBS was done visually by the crews of the helicopter and the air photo aircraft as they moved to and from their target colonies. Special attention was given to checking shallow lakes with islands, which were considered preferred colony sites for Ross's Geese (Ryder 1969, Kerbes 1978, Kerbes et al. 1983). The ground crew also made visual aerial estimates of nesting light geese from the helicopter as a supplement to the air photo coverage obtained from the photo plane. Working from Gjoa Haven, the photo plane did not have sufficient range to photograph all colonies. During June 1998, the helicopter crew visited 86 of 92 previously-known colonies and 10 new colonies. Occupied islands and extent of mainland colonies were marked on 1:50,000 maps. In cases where geese were nesting on islands, numbers were estimated using a hand counter, counting groups of 10 or 100. These counts included unknown numbers of non-breeders.

Colonies 2, 68, 81 and 86 were not covered by the photo plane but had too many geese to count directly from the helicopter. For Colony 2 we took the average of its estimate from 1988 (5,590 nesting birds; Kerbes 1994) and the number estimated from a helicopter on 13 June, 2005 (1,630 nesting birds; Alisauskas unpubl.) giving an estimate of 3,610 nesting birds for 1998. For colonies 68, 81 and 86 we used the area occupied by nesting geese (mapped out from the helicopter), and the area (km^2) of terrestrial habitat within those colony boundaries, calculated using GIS from Landsat imagery available at 30 meter resolution for QMGMBS. To estimate numbers of light geese nesting at each colony, we regressed 23 estimates of light geese at specific colonies in different years (Kerbes 1994) against their respective areas (see Fig. 4). We

compared quality of 4 models for prediction of mean ± 95%CL light geese using AICc; the models were (1) either linear or quadratic, or (2) with or without intercepts (Table 2); the best model was quadratic without an intercept { $N = \hat{\beta}_1(A) + \hat{\beta}_2(A^2)$ } with parameter estimates shown in Fig. 4.

2.5 1998 Central Arctic species and colour ratios

Data from the analyses of air photos, visual aerial surveys, and ground surveys were used to estimate the size and species composition of the colonies. All previously known major colony sites and almost all of the previously known smaller colony sites were surveyed by aerial photography and/or visual estimation from a helicopter. On major colonies their nesting areas were defined as **islands** (surrounded by water during the incubation period in June), or as **mainland** (on the shore of lakes, occasionally rivers), sometimes extending inland for several kilometres on major colonies, i.e., the four largest colonies, numbers 3, 9, 10 and 46. Those four, plus certain smaller colonies, constituted **key** colonies, at which both air photo and ground surveys were conducted. Air photos and ground work provided four types of data:

a) Counts of nesting Ross's and white Snow geese from scale 1:5,000 and /or 1:10,000 air photos at the large colonies and many of the small colonies;
b) Counts of nesting Ross's and white Snow geese visually estimated from the helicopter;
c) Counts of blue and white morph nesting birds (from scale 1:2,000 air photos) and/or flying non-breeding birds (from scale 1:5,000 or 1:10,000 scale photos), for an estimate of the proportion of blue morph Snows to total light geese;
d) Ground sampling of nesting birds for the proportions of Ross's, white Snows, and blue Snows among total light geese.

Data a, c, and d were obtained for all major and some of the other colonies. For these "key" colonies, the numbers, species and colour composition, with standard errors, were calculated after Kerbes et al. (1983). In some colonies, photo samples were available to calculate the percentage blue Snow Geese among total Snow plus Ross's, but no ground data were available on Snow:Ross's ratios. Assuming that those colonies had the same percentage blue among Snow Geese as the mean for the key colonies, we calculated the number of white Snows, and subtracted that number from the total white Snows plus Ross's to get the number of Ross's. In colonies with no samples for estimating colour morph or species ratios, we assumed that the percentage Ross's among Snow and Ross's, and the percentage blue Snow among Snow and Ross's, were the same as the mean values for the other colonies, extrapolating separately for western and eastern portions of the QMGMBS. The Armark River (Fig. 3) separated west from east, based on historic differences in species and colour ratios between those areas (Kerbes 1994). Standard errors could not be calculated for the estimates of Ross's and Snow numbers at colonies where independent ground surveys were not conducted.

3. Results

In the **Eastern Arctic** in June 1997 we surveyed 26 colonies containing 3,075,000 nesting Snow Geese (Fig. 2, Table 3). These totals included small but unknown numbers of Ross's Geese scattered within the Snow Goose colonies. An exception was the concentration of nesting Ross's Geese within the McConnell River Snow Goose colony on West Hudson Bay, where we estimated a minimum of 23,500 nesting Ross's Geese.

In the **Central Arctic** in June 1998 we estimated 1,259,900 nesting light geese (740,600 Snows and 519,300 Ross's, Tables 4 and 5, Fig. 3) in 79 occupied colonies. Most colonies were in or near the QMGMBS, with 73 occupied colonies containing 651,700 Snows and 495,100 Ross's. The remainder were east and north of the QMGMBS, where we recorded 88,800 Snow and 24,200 Ross's geese nesting in 6 colonies. We surveyed 90 (94%) of the 96 previously known light goose colony sites in the Central Arctic (the 6 colony sites not visited had all held small numbers in previous surveys). Of the 90 sites visited, 23 in the QMGMBS were not occupied. We recorded 12 previously unknown colonies: 10 in the QMGMBS and 2 to the east of the QMGMBS.

The Mid-continent Snow Goose Population, combining its Eastern and Central Arctic portions, therefore contained an estimated minimum of 3,815,600 nesting birds in 1997-98.

4. Discussion

4.1 Eastern Arctic 1997

Photo surveys of all known Eastern Arctic colonies were done in 1973 (Kerbes 1975) and 1997. Between those years air photo estimates were obtained in 1979 on Baffin and Southampton islands (Reed et al. 1987) and at Cape Henrietta Maria (Anghern 1979); and in 1980 on West Hudson Bay (Kerbes et al. 1990). Cooke et al. (1983) did a ground survey at La Pérouse Bay in 1979. In the following, we discuss our 1997 results particularly in relation to those of 1979-80.

In June 1997 we documented 26 colonies in the Eastern Arctic containing almost 3.1 million nesting Snow Geese, as opposed to 16 colonies containing about 1.1 million in 1979, an almost 3-fold increase in the 18 years between surveys (Table 3, Fig. 2). In 1997, the majority (56%) of nesting birds were on Baffin Island, with 24% on Southampton Island, 7% on West Hudson Bay, and 13% on South Hudson Bay. The respective regional proportions in 1979 were 40%, 21%, 28%, and 11%, showing that the proportion on West Hudson Bay has decreased to one quarter of its earlier value, while the proportions in the other three regions, especially Baffin Island, have increased.

4.1.1 Baffin Island colonies

South west Baffin Island (Fig. 5, Table 3) probably supports the largest goose nesting ground in the world. Nesting Snow Geese extended almost continuously for 300 km from Bowman Bay to Taverner Bay along the shore of Foxe Basin, comprising 4,600 km^2 of occupied nesting area in 1997. The "mega-colony" on the Great Plain of the Koukdjuak was divided into three colonies: Koukdjuak River, Cape Dominion and Bowman Bay by Cooch (1961). We have followed that convention, as did Kerbes (1975). However, Reed et al. (1987) used different border definitions, making a combined Koukdjuak-Dominion colony and a redefined Bowman Bay colony. Except for reports of scattered occasional nesting, no additional colonies outside the mega-colony had been documented by previous studies, up to and including the 1979 photo survey (Kerbes 1975, Reed et al. 1987).

Baffin Island's estimated total numbers of nesting Snow Geese (Table 3, Fig. 6) changed little from 1973 to 1979, but they increased 3.8 fold from 1979 (454,800 birds) to 1997 (over 1.7 million). That increase was made up of a nearly equal rate of growth at the Koukdjuak, Dominion, and Bowman colonies, the appearance of four small new colonies (Garnet Bay, Cory Bay, Prince Charles Island, Air Force Island) and one major new colony (Taverner Bay).

Taverner Bay and other coastal areas north of Koukdjuak River, and the islands in northern Foxe Basin, were reported to be the range limit of the Lesser Snow Goose, where they overlapped with the range of the Greater Snow Goose (*Chen caerulescens atlantica*; Kerbes 1975, C. Elliott, pers. comm., Reed et al. 1980, Anonymous 1981, Boyd 1989, Reed et al. 1998). Until the 1980s those areas, including Longstaff Bluff and Rowley Island, were considered to be summer habitat for low numbers of moulting non-breeders and only intermittent scattered nesting of Lesser Snows. However, from visual surveys flown in 1979, 1983 and 1984, Gaston et al. (1986), reported that Lesser Snows were regularly nesting north of the Koukdjuak River. That was confirmed by our survey in 1997.

In 1997 we recorded a major new colony at **Taverner Bay** (Fig. 7) of 469,300 nesting birds, 67% blue. Two new colonies on **Air Force and Prince Charles islands** (Fig. 5), northwest of Taverner Bay, were documented by S. Pepper and V. Johnston (unpubl.), in a concurrent independent survey of all species of birds using visual transects from a helicopter which sampled all parts of those islands. They estimated 17,300 nesting Snow Geese on Air Force and 1,700 on Prince Charles. They did not obtain an estimate of the Snow Goose colour ratio, and they considered the entire islands to be nesting area, with very low nest densities (Table 3).

The **Koukdjuak - Dominion - Bowman** "mega-colony" increased 2.6 times, to 1.2 million nesting birds from 1979 to 1997 (Figs. 6, 8, 9, 10). Total occupied nesting area did not change significantly. Weighted mean colour ratio was 72.8% blue in 1997, an increase from 64% in 1979 and 61% in 1973 (Reed et al. 1987, Kerbes 1975).

To the southwest of the main colonies, on the north shore of Foxe Peninsula, **Cory Bay** and **Garnet Bay** were noted by Cooch (1961) as possible colonies, but no nesting birds were reported

in subsequent surveys (Kerbes 1975, Reed et al. 1987, Gaston et al. 1986). In 1997 there were 42,500 nesting birds at Cory and 2,200 at Garnet, with 80% blue (Fig. 11).

Helicopter supported surveys and banding of Cackling Geese (*Branta hutchinsii*), Brant and Snow Geese on the Great Plain of the Koukdjuak during the summer moulting and brood-rearing period have been conducted since 1987 (Caswell unpubl.). The samples of Snow Geese banded in 1997 provided the colour ratios used to extrapolate total Snow Geese from our photo counts of the white morph nesting geese. They were grouped (Table 3) for Taverner Bay and Koukdjuak River (66.7% blue) and for the southern colonies (80.3%). In August 1997, the estimate within the area covered by visual transect counts was 1,238,000 breeders and 201,000 non-breeders, for a total of 1,439,000 adult-plumaged birds (Caswell, unpubl.). In our June photo survey we estimated 1,670,000 nesting birds in the Taverner Bay to Bowman Bay colonies, the region covered by Caswell's August survey. The results of the two surveys, considering the confidence limits of the estimates, are relatively close.

4.1.1.1 Ross's Geese on Baffin Island

In August 1993 Caswell (unpubl.) captured a few Ross's Geese during banding, providing the first evidence of the species on Baffin Island, and in 1994 he captured a further 20 adult and 30 young Ross's Geese. From an August 1995 visual survey Caswell (unpubl.) estimated a minimum of 950 breeding adults and 1,750 young in the area from Cape Dominion to north of the Koukdjuak River. The area from Cape Dominion south to Bowman Bay was not surveyed, so the total Ross's Geese may have been much higher, and a few thousand Ross's were probably nesting on Baffin in 1997.

4.1.2 Southampton Island colonies

The number of nesting Snow Geese in 1997 (721,200) was an increase of more than three-fold from 1979. Total size of occupied nesting area increased 2.7-fold, but the proportional distribution among colonies changed little from 1979 to 1997. (Table 3, Figs. 12 and 13).

Boas River, (Fig. 14) with 529,100 nesting birds in 1997, remained the largest colony, containing about 75% of the island's Snow Geese in both 1979 and 1997. It increased 3-fold in both number of nesting birds and occupied area from 1979 to 1997. West Boas River, identified as a small colony along the coast on the west edge of the main colony in 1973 (Kerbes 1975) and 1979 (Reed et al. 1987), was not occupied in 1997. However, the **Ell Bay** colony, on the north west edge of the Boas River colony, increased over 4-fold in number, to 22,600 nesting birds, and its area increased 3-fold in size, merging with the Boas River colony.

East Bay colony (Fig. 15), with 144,800 nesting birds in 1997, tripled in numbers and doubled in area from 1979 to 1997. **Bear Cove** colony (Fig. 16), with 11,800 nesting birds in 1997, doubled in number with a modest increase in area from 1979 to 1997. The colonies of **Sutton River** (931 nesting birds, Fig.16) and **Coral Harbour** (11,900 nesting birds, Fig. 17) had not been surveyed before 1997. Moulting flocks and broods of Snow Geese have been recorded in the Coral Harbour colony area as early as 1980 (Abraham and Ankney 1986, Abraham unpubl.). Local Inuit advised that this colony had become established by the mid-1980s, and they have been collecting

eggs there in spring (David Netser pers. comm.), which may explain the low nest density there in 1997.

Colour ratios of the Snow Geese in 1997, based on a ground count of nesting birds at East Bay, taken by M. Wayland (unpubl.), and on samples of flying birds counted on air photos from Boas River, were similar to estimates of 1979 (Table 3). In 1997, the percentage blue was higher at East Bay and Coral Harbour (45.2%) than it was in the more western Southampton colonies (24.8%). That pattern was similar to 1979: 46% at East Bay and 23% at Boas River (Reed et al. 1987).

4.1.2.1 Ross's Geese of Southampton Island

Ross's Geese were recorded nesting at East Bay and Boas River as early as the 1950s (Barry and Eisenhart 1958). Canadian Wildlife Service Banding Office records show that in the 1950s and 1960s there were only 9 (0.02%) Ross's in a total of 39,032 light geese banded on Southampton Island. Further banding there in 1979 recorded an increase, with 10 (0.39%) Ross's in a total of 2,558 Snows and Ross's banded (Abraham and Ankney 1986). During banding of light geese on Southampton Island from 1991 to 2001, a total of 214 Ross's Geese were marked. However, because they may have been selectively captured in most years that total cannot be used to estimate a Snow:Ross's ratio. Therefore, a small but unknown proportion of our total estimated Snow Geese on Southampton in 1997 were Ross's Geese.

4.1.3 West Hudson Bay Region colonies

This region differs from the other Eastern Arctic regions in that it has been surveyed more frequently, and its numbers and distribution have shown a different pattern from the steady growth of other regions. Air photo surveys of all of the colonies of West Hudson Bay were obtained in 1973, 1977, 1978, 1980, 1985 (Kerbes 1975, 1982, Kerbes et al. 1990); 1990, and 1997. Numbers and distribution of nesting geese have changed considerably over that period (Figs. 18 and 19). Total number declined from 1973 to 1980, recovered to a historical high of 420,000 in 1985, and declined again to half that level in 1990, where it remained in 1997. Percentage of blue morph among Snow Geese banded on West Hudson Bay in 1997 was 24.6%, (A. Didiuk, unpubl.), which was higher than its average (19%) in 1980 (Table 3).

The decline in Snow Goose numbers at the Wolf Creek and McConnell River colonies has been related to deteriorating habitat due to grubbing and over-grazing (Kerbes et al. 1990) and possibly to disease complications (Wobeser et al. 1983, Gomis et al. 1996). From 1980 to 1997 the total occupied nesting area on West Hudson Bay actually increased from 584 km^2 to 759 km^2, but the average nesting density declined from 543 adults/km^2 to 279 adults/km^2 (Table 3). Ground studies in 1985 and 1986 (Kerbes et al. 1990) found evidence that the geese had negatively affected their feeding habitats, especially around McConnell River, where large areas of exposed peat had appeared. That confirmed long suspected concerns that the increasing numbers of Snow Geese were having a serious impact on the region's vegetation communities (Lieff 1973, Kerbes 1982). Impacts of grubbing and over-grazing, though not as fully documented as on South Hudson Bay, have likely caused the shift of nesting Snow Geese away from McConnell River and Wolf Creek

to areas farther north and south in the West Hudson Bay region. Additionally, many may have emigrated to colonies in the Central Arctic (Kerbes 1982, 1994, see Section 4.2.1.1 below).

McConnell River (Fig. 20), the major colony of West Hudson Bay until 1997, has the most complete historical documentation of any light goose colony of the Canadian Arctic. MacInnes and Kerbes (1987) reviewed its exponential growth from 14,000 nesting birds in 1941 to 326,000 in 1973, which was followed by a decline to 231,000 in 1980 (although 1980 was a late year in the eastern Arctic and part of the decrease could be attributable to poor nesting conditions). Subsequent inventories showed 265,000 in 1985 (Kerbes et al. 1990), and 232,000 in 1990 (Kerbes, unpubl.). Although the colony's occupied area changed little after that, its number declined sharply (72%), to 65,500 nesting birds by 1997 (Table 3). Further, as noted below, an unknown number of those were Ross's Geese.

Maguse River colony, first recorded in 1973 with 1,000 nesting birds (Kerbes 1975), was the largest in the region in 1997, with 80,900 nesting birds. It increased over 5-fold in number and 50% in area since 1980 (Fig. 21, Table 3).

Declines were evident in 1997 for the small colonies at **Wolf Creek** (4,400 nesting birds - less than one tenth of its number in 1980, Fig. 22) and **Tha-anne River** (34 nesting birds - down from 2,800 nesting birds in 1980, Fig. 23). The low number at Tha-anne River in 1997 may have been due to an unusually large amount of "aufeis", or river ice which sometimes accumulates over these deltaic islands in winter, not melting early enough for the geese to nest (Hanson et al. 1972).

The extensive low density **South McConnell** colony had 26,800 nesting birds in 1997, and was about 50% larger in both area and number than it was in 1980 (Table 3, Fig. 23). The new **Geillini River** colony, a low density strip of 34,000 nesting Snow Geese in 1997, extended along the coast south from Tha-anne River to near the Manitoba border (Fig. 24). Moulting flocks, but no nesting birds, had been recorded there previously (Kerbes and A. Didiuk, unpubl.).

4.1.3.1 Ross's Geese of the West Hudson Bay Region

MacInnes and Cooch (1963) reported the first nesting records of Ross's Geese on West Hudson Bay, at McConnell River, and they recorded 6 Ross's (0.07%) among 9000 light geese captured for banding there in 1959-60. Ten years later, Prevett and MacInnes (1972) recorded 88 Ross's (0.16%) among 55,322 light geese in field-frequency counts at McConnell River in 1969-70. In 1977 and 1978 (Canadian Wildlife Service Banding Office data) 120 Ross's (0.15%) were banded among 78,960 light geese. Ground work in 1981, 1985 and 1986 (Kerbes, unpubl.) and information from local Inuit hunters (Peter Suwarksiork and R. Forsyth, pers. comm.) indicated that the Ross's remained uncommon on West Hudson Bay. In 1991, Randy Forsyth, Canadian Wildlife Service enforcement co-ordinator (1994 unpubl. Occurrence Report), started a series of annual spring patrols from Arviat to the McConnell River Migratory Bird Sanctuary. He reported that, while checking large numbers of Snow Geese harvested by local subsistence hunters, he encountered only one Ross's Goose in 1991, none in 1992, and one in 1993. He observed that Ross's Geese had remained so rare that it was not part of the local traditional

hunting knowledge. That changed dramatically in 1994, when he estimated that 60% of the spring harvest was Ross's Geese.

On arriving at Arviat in 1994 for his regular spring patrol, Forsyth was advised immediately by the local Inuit that they were encountering far more of the little Ross's Geese than ever before in their regular spring hunt. On 8 June 1994, Forsyth and his local guide Joe Savikataaq proceeded by ATV south from Arviat, and began seeing Ross's Geese among the nesting Snow Geese as they continued south of Wolf Creek. In the northern part of the McConnell River Snow Goose colony, after passing a zone of low density nesting Snow Geese, they encountered an impressive concentration of nesting birds, all of them Ross's Geese. Forsyth estimated that they numbered many thousands, and their nest density was very high, compared to that of the Snow Geese. Forsyth and Savikataaq returned to the area again the next day, and following the suggestion of J. Hines, Forsyth recorded more data, including some GPS coordinates.

The data showed that this new Ross's colony was in the same area which, from our 1997 photo analyses (see below), we labelled Ross's nesting area Number 1 (Fig. 25). Later in June 1994, Robert Mulders (pers. comm.), regional biologist with NWT Renewable Resources, visited this Ross's colony, collected data on clutch sizes and hatching of nests, and essentially confirmed Forsyth's description of the colony.

Forsyth (pers. comm.) did not continue his spring patrols after 1994, but on 8 June 1995 Robert Bromley (pers. comm.), waterfowl biologist with NWT Renewable Resources, investigated the area with Joe Savikataaq. They visited "Area 1" reported by Forsyth in 1994 and found it to be occupied again by Ross's Geese. Savikataaq estimated that the area was larger but less dense than when he had been there with Forsyth in 1994. Using a 20X telescope to examine a sample of 2,834 nesting Snows and Ross's, Bromley estimated that 90.3% were Ross's Geese. They visually estimated that there were some 32,500 total nesting birds in "Area 1", or 29,500 Ross's Geese. Allowing for other areas with lower proportions of Ross's, Bromley (unpubl.) estimated that there were probably over 40,000 Ross's Geese nesting in the McConnell River area.

Given the lack of any evidence of large numbers of Ross's Geese in that area prior to that time, Ross's Geese apparently established their McConnell River colony as a sudden event in spring 1994. The Snow Goose colony there had been initiated much earlier, prior to 1942, probably by migrants that stopped en route to their breeding grounds on Southampton Island (MacInnes and Kerbes 1987). The McConnell Ross's Goose colony also must have started in a similar but much more abrupt way, with several tens of thousands of migrant Ross's stopping and setting up a new colony. Those "short-stopped" migrants were most certainly initially bound for the Central Arctic, because there has been no evidence of large Ross's Goose colonies on Southampton Island or elsewhere in the Eastern Arctic.

McConnell River colony is on the main migration route of Snow Geese going to Southampton Island, but not on that of Ross's Geese going to the Central Arctic. In spring, after staging on agricultural areas in eastern Alberta and western and central Saskatchewan, Ross's Geese continue on to their breeding grounds in the Central Arctic (Ryder and Alisauskas 1995). They likely follow a direct route, probably 300 km or more inland from the Hudson Bay coast. Therefore, in

spring 1994 some unusual event, possibly weather related, induced a large mass of migrant Ross's Geese to divert eastward and to settle at McConnell River.

In June 1997, ground surveys between Arviat and McConnell River confirmed that the Ross's were concentrated in "Area 1" as reported by Forsyth in 1994 and Bromley in 1995, and on islands and shoreline of the large lake at the north end of the McConnell colony (A. Didiuk, unpubl.). Area 1 was in the large area of exposed peat noted by Kerbes et al. (1990) and the Ross's Geese were nesting in low areas with limited relief, while Snow Geese outside Area 1 were nesting on more upland areas with hummocks and low shrubs. Ross's Geese were scattered among nesting Snow Geese in other parts of McConnell River colony and probably other colonies of the region, but due to limited time and logistics, the ground crew was not able to collect data for calculating a Ross's:Snow ratio (A. Didiuk pers. comm.). Even though we did not have a species ratio to apply to our photo estimate of total nesting white Snows and Ross's geese, we were able to obtain a minimum estimate of the number of Ross's Geese at McConnell River, where we had ground truth data proving the existence of concentrations of nesting Ross's Geese. We did a total count of all white morph Snow and Ross's Geese from air photos which covered all of the northeast part of the McConnell colony (Fig. 20 and 25), then isolated the areas with extremely high densities, which we assumed to be totally Ross's Geese. The distribution of white nesting birds per grid square (each equal to 100m X 100m of surface area) was examined on our data sheets. Squares with between 10 and 20 birds were uncommon, providing a suitable break-point for separating the high density Ross's Goose areas from the surrounding lower density Snow Goose areas. We therefore defined the areas made up of squares with 20 or more birds as the areas of high density Ross's Goose nesting. Our resulting map of Ross's Goose areas (Fig. 25) agreed with the June 1997 ground observations (A. Didiuk, pers. comm.).

Those high density squares totalled 23,476 Ross's Geese on 3.5 km^2 (= 3,350 nesting pairs/km^2), located in 14 discrete areas (Fig. 25). Most (70%) were in Area 1, with 12% in Areas 2 to 9 nearby, mainly to the southwest. The remaining 18% (Areas 10 to 14) were on islands and peninsulas in the lake at the north end of the McConnell colony. We emphasize that 23,476 nesting Ross's Geese at McConnell River was a minimum estimate for the West Hudson Bay region. To obtain a complete estimate we would need to add the unknown number of Ross's that nested at lower densities, mixed in with nesting Snow Geese. Bromley, as noted above, estimated a minimum of 40,000 Ross's on West Hudson Bay in 1995. Probably there were at least that many there in 1997; correspondingly, our estimate of nesting Snow Geese in 1997 would have been fewer than 212,000. Summer banding of Snow and Ross's geese from 1994 to 2002 in areas south of Arviat showed that the proportion of Ross's Geese has increased in that area (A. Didiuk and K. Warner, pers. comm.). The banded samples are not valid measures of the species ratios, however, because each year's target sample has been 1,000 of each species. Future air photo surveys should be accompanied by sufficient ground work to estimate species ratios in all parts of the West Hudson Bay region.

Thus, in contrast to the significant decline in nesting Snow Geese at McConnell River from 1985 to 1997, a large number of Ross's Geese apparently established a nesting colony in 1994 within the area where habitat was previously impacted by the Snow Geese. Given the concerns of over-population and habitat degradation caused by Snow Geese, it is also important to investigate how the Ross's Geese apparently thrive on these habitats, and whether the increasing numbers of

Ross's are having further negative impacts on the ecosystem. Such investigations began in 2003 (J. Caswell, University of Saskatchewan, pers. comm.).

4.1.4 South Hudson Bay Region colonies

The South Hudson Bay Region extends along the Manitoba and Ontario shores of Hudson and James bays and includes Akimiski Island, Nunavut (Fig. 26). Total number of nesting Snow Geese increased 3.4 fold since 1979, to 408,700 in 1997 (Table 3, Fig. 27). The productivity of geese in this region was checked almost annually from 1957 to the 1970s by Hanson et al. (1972), and periodically since then by the Ontario Ministry of Natural Resources (Abraham, unpubl.). In addition to its two main colonies, at La Pérouse Bay and Cape Henrietta Maria, a number of small groups of 200 nesting birds or less were intermittently recorded at many sites on the long coastline of this region. As noted below, some of those transient nesting groups became colonies at Knife River, West Pen Island, Shell Brook (Abraham et al. 1998) and Akimiski Island, the southernmost Snow Goose colony in the world (Abraham et al. 1999).

La Pérouse Bay colony grew slowly from a few hundred birds first reported in the 1950s to 5,600 nesting adults in 1972 (Kerbes 1975), and 8,800 in 1979 (Cooke et al. 1983). Growth was more rapid after that, with air photo estimates of 29,400 in 1985 and 46,000 in 1990 (Kerbes, unpubl.). In 1997, it had 58,700 nesting birds, more than a 10-fold increase since 1972 (Table 3, Fig. 28). Its occupied nesting area expanded 16-fold from 1972 to 1997 (Fig. 29).

In 1997, most of the **Cape Henrietta Maria colony**, including two small expansion areas to the west of the main colony, was photographed and analyzed (Fig. 30). Unfortunately, due to persistent fog and low cloud on the coast, a large, high density section of the main colony (Stratum F in Fig. 30) could not be photographed. We analyzed the photo cover available, and our photo estimates for those areas compared favourably with results based on visual transect counts in a separate June 1997 survey by helicopter (Abraham et al. 1998, Ross et al. 2003). The comparison was approximate because the edge of the visual survey could not be precisely calculated to correspond with the border between the area analyzed on photos and the area not photographed. Rather than attempt to add the transect estimate for the fogged-in section to our photo estimate of the remainder of the colony, we have used the helicopter transect estimate for the whole colony. Abraham et al. (1998) estimated 320,000 nesting birds on 277 km^2 in 1997, an almost 3-fold increase in numbers and a 4-fold increase in area since 1979 (Table 3, Fig. 31). Annual visual surveys since 1997 have shown that the number of birds nesting at Cape Henrietta Maria has declined (Abraham and Ross, unpubl.).

Knife River (Fig. 32), with 4,700 nesting birds in 1997, showed a 5-fold increase from 908 birds recorded from a total air photo count in 1978, when it occupied only the short coastal strip between the Seal and Knife rivers (Kerbes, unpubl.). In 1997, the **West Pen Island** colony (Fig. 33) had 16,500 nesting birds and the **Shell Brook** colony (Fig. 34) had 5,300 nesting birds.

Akimiski Island (Table 3, Fig. 35) had at least 3,450 nesting Snow Geese in June 1997, as estimated from ground searches of nests by Abraham et al. (1999). They reported that after showing intermittent nesting of small numbers beginning in at least 1958, Snow Geese have nested annually at this colony since 1968, and the total number increased 10-fold between 1974 and 1997.

Air photos of the Akimiski Island colony were not obtained in 1997, but we analysed photos from 1995, estimating 2,500 nesting birds, which corroborated the minimum (2,016) obtained by ground count that year by Abraham et al. (1999).

Snow Goose colour morph ratios for 1997 were estimated from 1995-1999 banding samples (from R. Rockwell, unpubl.) at La Pérouse Bay and from 1997 photo samples of flying non-breeders at Cape Henrietta Maria. The estimated frequency of the blue morph increased between 1980 (27%) and 1997 (36%) at La Pérouse Bay, but decreased between 1979 (71%) and 1997 (65%) at Cape Henrietta Maria.

4.1.4.1 Ross's Geese of South Hudson Bay

Ross's Geese on South Hudson Bay were first reported to be nesting in the Snow Goose colonies at La Pérouse Bay in 1972 (Ryder and Cooke 1973), at Cape Henrietta Maria in 1975 (Prevett and Johnson 1977), and on Akimiski Island in 1985 (Carpentier 1989). Numbers of Ross's Geese have increased at La Pérouse Bay and Cape Henrietta Maria and probably other parts of South Hudson Bay, but not on Akimiski Island, where they are still rare. At La Pérouse Bay, up to 100 Ross's geese have been banded each year since 1998, and it is estimated that approximately 1,000 pairs nested in 2003 and 1,500 pairs nested in 2004 (R. Rockwell, pers. comm.). At Cape Henrietta Maria, Abraham (2002) estimated from banding ratios that there were 280, 360, and 2,250 pairs of Ross's Geese nesting there in 2000, 2001 and 2002, respectively.

4.2 Central Arctic 1998

Of the estimated 1.3 million light geese nesting in the Central Arctic in 1998 (Tables 4 and 5, Figs. 36 and 37), 91% were in the QMGMBS area. All those were within the boundaries of the QMGMBS, except for seven small colonies (11, 14, 15, 16, 19, 41, 42) on its eastern boundary (the mid-line of the Kaleet River), and four (12, 13, 18, 62) within about 10 km to the east of that boundary. Additional colonies were at Jenny Lind Island, about 100 km to the north of the QMGMBS; near Elliot Bay, about 20 km to the east; on Adelaide Peninsula, about 50 km to the north east; and at Inglis River and Kuuguarjuk Lake, about 200 km to the northeast (Fig.36).

Unlike the colonies of the Eastern Arctic, the origins of which were associated with coastal river deltas (Cooch 1961), the Central Arctic colonies originated on islands in freshwater lakes. The first colonies documented in the Central Arctic contained almost exclusively Ross's Geese nesting only on islands in shallow lakes in the QMGMBS area. Such lakes melted early enough in spring to provide protection from depredation by arctic fox (*Alopex lagopus*) (Gavin 1947, Hanson et al. 1956, Ryder 1969, 1971). More recently, however, a higher proportion of colonies found by Alisauskas and Boyd (1994) included deltaic islands as well as islands in fast-flowing rivers.

Significant numbers of Snow Geese were nesting among the Ross's Geese by 1965 (Ryder 1969, 1971), and by 1976 both species had begun nesting on the mainland (lake shores) at the major colonies (Kerbes et al. 1983, Kerbes 1994). Since then, the numbers of both species have increased rapidly (Fig. 37, Table 6). The percentage of Ross's Geese, estimated at 77% in 1965,

declined to 58% in 1976, and to 46% in 1982. It seems to have stabilized since then, with 40% in 1988 and 43% in 1998. In the QMGMBS the number of Snow Geese increased at a faster rate than the Ross's Geese over the 23-year period from 1965 to 1988, with annual average rate of change of 7.7% for Ross's and 15.4% for Snows (Kerbes 1994). However, over the 10-year period 1988 to 1998, the rate for Ross's Goose increase (10.7%) was higher than that of Snow Goose increase (8.8%).

4.2.1 Colonies of the Queen Maud Gulf Migratory Bird Sanctuary

Although a total of 102 colonies have been recorded from 1965 to 1998 in the QMGMBS area, most nesting geese have been in only a few large colonies (Tables 5 and 6, Fig. 38). In 1965 and 1976, approximately 70% of total geese were in colonies 3, 9 and 10, while in 1982, 1988, and 1998 about 90% were in colonies 3, 9, 10 and 46. The number of occupied colonies increased from 37 in 1965-67 to 73 in 1998. That increase reflects the number of "new" or previously undocumented, colonies recorded in each survey year, with 5 new colonies in 1976, 7 in 1982, 17 in 1988, 26 in 1990-91, and 10 in 1998. The status of colonies for each survey year is summarized in Table 7. Many of the smaller colonies were not occupied each year, e.g. of the 66 colonies known to have been occupied up to 1988, only 39 (59%) were occupied by nesting geese in all years in which they were checked, from date of discovery to 1998.

Occupation by nesting geese at a colony in a given year is affected by many factors, especially the amount of snow cover at the beginning of the nesting season and the severity of weather and predation during the nesting period. Late snow-melt can totally prevent nesting, and severe pressure from weather or predators on eggs can destroy all nesting attempts, especially at the smaller colonies (Barry 1962; Ryder 1967, 1972). Streams eroding through colony lake shores and draining the lakes presumably led to the abandonment of Colony 38 between 1982 and 1988 (Kerbes, unpubl.), and of Colony 83 between 1991 and 1998 (Alisauskas unpubl.).

4.2.1.1 Major Colonies

Colony 3 (Karrak Lake, Fig. 39) was the site of research on the breeding ecology of light geese in 1966-1970 by Ryder (1971, 1972), in 1976 by McLandress (1983), and, since 1991, by Alisauskas et al. Rapid expansion (Fig. 40) of nesting area of Colony 3 from 1988 to 1998 "absorbed" its neighbouring small Colonies 51 and 65, whose numbers are now included in the 1998 total for Colony 3. It held the largest percentage of nesting geese in the QMGMBS in the surveys of 1965-67 (39%), 1976 (41%), 1982 (54%), and 1988 (46%). However, in 1998 its percentage fell to 38%, being surpassed by Colony 10 with 42% (Table 6, Fig. 38).

Colony 10 (Fig. 41), approaching a half million nesting birds, and the largest colony of the Central Arctic in 1998, is located about 10 km east of McNaughton Lake. It has shown the fastest rate of increase among the major colonies since 1982. Number of birds at Colony 10 increased over 3-fold from 1982 to 1988, and over 4-fold from 1988 to 1998 (Fig. 42 and 38, Table 5). In contrast, Colony 3 had a 2-fold increase for each of those periods. Colony 10, being the furthest east of the

major colonies, may be receiving a higher proportion of immigrant Snow Geese coming from Eastern Arctic colonies (see Kerbes 1994). The higher percentage blue (Table 4) among Snow Geese at Colony 10 (22.6%) than at Colony 3 (15.3%) provides evidence for more immigrants at Colony 10.

Colony 9 (Fig. 43, Table 5), located 130 km upstream from the coast on the Simpson River, is the most inland of the major colonies. It expanded steadily from 1965 to 1988, absorbing Colony 36 by 1982. However, although its occupied area continued to expand from 1988 to 1998, its population size decreased by 52%, from 75,000 to 36,000 nesting birds. The decrease was surprising, given the huge increases at other major colonies and many smaller colonies in the QMGMBS. It may be that light geese are abandoning this colony because of persistent severe predation and destruction of nests by grizzly bears (*Ursus arctos horribilis).* Grizzlies were seen foraging at Colonies 68 and 81 in 1998. In the Western Arctic grizzlies probably have been a major factor limiting the numbers of Snow Geese at the Anderson River and Kendall Island Snow Goose colonies (J. Hines, pers. comm.).

Colony 46 (Fig. 44, Table 5), located about 20 km west of McNaughton Lake, has grown 27-fold since being first documented in 1982. A large part of that growth was due to its absorption of Colonies 27 and 45 between 1988 and 1998.

4.2.1.2 Other Colonies

In 1997, in addition to the four major colonies, only 12 (Colonies 2, 8, 13, 15, 18, 19, 29, 68, 81, 86, 88 and 101) were estimated to have 1,000 or more nesting light geese each, while 51 colonies had less than 1,000. Six colonies (27, 36, 45, 51, 65 and 76) had been "absorbed" by larger neighbouring colonies (Fig. 36, Table 5). As noted in Methods above, we estimated numbers of nesting geese at Colonies 68, 81 and 86 from their 1998 occupied area and a density estimate based on a regression of number of birds against occupied area at other colonies. These three colonies were first recorded in 1990-91 by Alisauskas and Boyd (1994) who estimated that Colony 68 was in the 2,000 to 20,000 nesting bird category, Colony 81 was in the 200 to 2,000 category, and Colony 86 was in the 20 to 200 category. Our estimates for 1998: 52,300, 3,700, and 14,000 for Colonies 68, 81 and 86, respectively, indicate that all three have grown rapidly.

Tingmeak River, located in the extreme north west corner of the QMGMBS, about 50 km north west of Colony 74 (Fig. 36), was identified as a colony by Bromley and Stenhouse (1994) during post-hatch aerial surveys of waterfowl, by airplane on 21 July 1989 and helicopter on 24 July 1991. They indicated that the colony was at the mouth of the river, and they estimated about 2,000 geese were present in the surrounding area in each of those years. Although they assumed those birds to be Snow Geese, they probably included Ross's Geese, given the colony's proximity to other colonies with Ross's Geese in the QMGMBS. This colony was not visited in 1998.

4.2.2 Colonies outside the Queen Maud Gulf Migratory Bird Sanctuary Area

Elliot Bay Colony (Figs. 36 and 45), with 45,900 nesting light geese in 1998, was the largest of the Central Arctic colonies outside the QMGMBS. This colony, located about 3 km inland from Elliot Bay, which connects to Chantrey Inlet and Rasmussen Basin, is 50 km east of Colony 10, and had not been covered in previous photo surveys. It was known to local Inuit at Gjoa Haven (Paul Iqalak, pers. comm.) and has probably existed for some time. A. Goodman (pers. comm.) saw nesting geese there in 1979 during a habitat mapping flight. Recorded for the first time in 1998, **Adelaide Peninsula 1** (200 nesting birds) and **2** (13,000 nesting birds) were located about 55 km north east of Colony 101 (Fig. 36). We assumed that the Adelaide and Elliot Bay colonies had the same percentage of Ross's Geese as the eastern colonies of the QMGMBS.

Jenny Lind Island Colony (Fig. 36 and 46) lies about 100 km north of the QMGMBS. In 1988, it held 39,200 nesting light geese (Kerbes 1994), but in 1998 it held only 19,300, about half its previous number. With no ground survey in 1998, we assumed the proportion of Ross's was 3%, as it was in 1988. The decrease in numbers was not surprising - in fact a much bigger decrease had been expected. The island has had a very large population relative to its very limited habitat, with obvious potential, and anecdotal evidence, for starvation, particularly of moulting adult geese and their young, unable to fly from the island to seek food resources on the mainland or elsewhere (see Kerbes 1994, Kerbes et al. 2005). Parmelee et al. (1967) were the first to report Snow Geese on Jenny Lind Island, recording 70 adults in each of 1962 and 1966, and estimating that the island supported about 210 adults. Numbers had begun to rise rapidly by 1982 when R. Decker (pers. comm.) estimated 3,000 to 4,000 adult Snow Geese on the island. In July 1985 McCormick and Poston (1988) used visual transects from a helicopter to sample the whole island, estimating 54,000 total light geese. In June 1988 Kerbes (1994), using air photos and ground sampling, estimated 38,100 nesting Snows and 1,100 nesting Ross's on the colony. In July 1990 another aerial survey, using the methods of 1985, estimated 25,000 total light geese on the island, indicating that numbers had begun to decrease (Kerbes et al. 2005).

Inglis River Colony (Figs. 36 and 47), on the east shore of Rasmussen Basin, almost 200 km north east of the QMGMBS, was reported to have had several hundred nesting Snow Geese in 1975-1977 (Allen and Hogg 1978, McLaren and McLaren 1982). Hines et al. (2003) estimated there were 13,700 nesting Snow Geese at Inglis River in 1994 and 10,800 in 1995. We estimated 30,700 nesting birds there in 1998. That apparent large increase may have been due to a greater proportion of geese nesting, since Hines et al. (2003) had estimated there were 42,000 Snow Geese, including non-breeders, in the Rasmussen Basin area in 1994-95. We estimated, from a photo sample of nesting and non-breeding birds, that 21.8% of the Inglis River Snow Geese were blue morph, higher than the mean percentage (18.6%) of blues among Snow Geese at QMGMBS (Table 4), which may reflect a larger input of Eastern Arctic immigrants to Inglis River. Ross's Geese have not been recorded in the Rasmussen Basin area, except for two adults captured near Inglis River during banding of Cackling Geese and Greater White-fronted Geese (*Anser albifrons*) in 1995 (Kerbes unpubl.). **Kuuguarjuk Lake Colony** (Fig. 36), located about 40 km north of Inglis River, was first recorded by Hines et al. (2003) with 1,800 nesting Snow Geese in 1994 and 2,300 in 1995. In 1998, it had 4,300 nesting birds, all on islands in the lake. A sample count of flying non-breeding birds indicated that 27% of the geese were blue morph Snow Geese.

4.3 Methods of the 1997-1998 photo surveys

The periodic photo-based surveys to estimate numbers of nesting birds from 1973 to 1998 have been important for documenting the massive increase in Snow and Ross's goose populations. These estimates, and their 95% confidence limits, enable management agencies to monitor the status of these geese by colony, species, sub-population, and population, and to have a permanent record of distribution and abundance. These surveys have estimated the size of the "core" population segment – the number of adult nesting birds present on the colonies in June at the time of the survey. Total population consists of that segment plus the non-breeders, failed-breeders, and (post-hatch) the young of the year. Total population reaches its annual minimum just prior to hatch and its annual maximum at completion of hatch. Our estimates of June nesting birds represent only a portion, which varies by colony and year, of the total population of any colony or grouping of colonies. Non-breeders, which are adult-plumaged, similar in appearance to nesting birds, consist of yearlings and a variable portion of older birds that are not in breeding condition (Cooch 1958, Prevett 1972). Failed breeders are those nesting birds which, after initiating a clutch, lose their eggs before hatch.

The actual proportion of total population of geese in the fall flight represented by our estimates of nesting birds varies a great deal, depending on factors such as: 1) the current year's nesting phenology, with earlier snow melt allowing a greater proportion of potential breeding birds to nest; and 2) the previous history of annual production, i.e. a high production of young the previous year gives a higher proportion of non-breeders, and high production of young three or more years previously would give a higher proportion of potential nesting adult birds (see Lynch and Singleton 1964, Kerbes 1975, Owen 1980). For example, if we assumed that the autumn Mid-continent Snow Goose Population consisted of one third nesting birds, one third non-breeders plus failed breeders, and one third young of the year, our minimum estimate of 3.8 million nesting adults could mean that the total autumn population was over 11 million birds.

Obtaining air photos of the nesting colonies, weather permitting, is fast and efficient but analyzing photos is a slow and detailed process. It has long been hoped and expected that technology would provide computerized scanning and counting methods, which would increase the speed and decrease the cost of analyzing photos. As early as 1974, Dennis Bajzak (unpubl.) devised a computerized program to identify and count eiders at sea off the coast of Newfoundland (it was unsuccessful). Many claims have been made since, from different locations and species, but successful automated counts have been done only for near-perfect sample photos, such as flocks of Snow Geese swimming on water. The extreme variability of arctic substrates or "backgrounds" on the air photos of nesting light geese make it very difficult for automated counting of goose images. However, the search for a machine-based analysis method continues, such as our current investigation of image analysis software and high resolution scanning (Meeres, unpubl.). High resolution digital cameras newly developed for aerial photography also have potential for improving the efficiency of both obtaining imagery and the analysis procedure.

Photo-based surveys need supplementary ground work to provide an estimate of colour morph ratios and especially the proportion of Ross's among light geese. Until recently, the requirement was significant only in the Central Arctic, where 95% of the Ross's were presumed to nest. However, the nesting of significant numbers of Ross's Geese at McConnell River, and possibly

elsewhere in the Eastern Arctic, now makes it necessary to include ground surveys for Ross's wherever possible in future nesting surveys of both Central and Eastern Arctic colonies.

4.4 Coverage of the 1997-98 surveys

A comprehensive survey of nesting Snow and Ross's geese ideally needs to cover all colonies, from the largest to the smallest. The small colonies, even if occupied intermittently among years, are still important because any one of them has potential to become significantly large in future. For example, our current large colonies of Maguse River on West Hudson Bay and Colony 46 in QMGMBS were very small when first recorded. We sought to survey all previously known colony locations and find possible new colonies of Snow and/or Ross's geese in the Eastern and Central Arctic in 1997-98. Most of the potential range was inspected for the existence of colonies during our photo plane and helicopter flights. However, given the huge size of the area and the expanded numbers of geese and their colonies, no doubt we missed some small colonies, and possibly some colonies of significant size. The following reviews our 1997-98 coverage by region.

Baffin Island – Nesting Lesser Snow or Ross's geese have not been reported outside the region of southwest Baffin and Foxe Basin which we covered in 1997. The northern nesting area of Lesser Snows overlaps with that of Greater Snow Geese in the north Foxe Basin area (Anonymous 1981), and all evidence available shows that only Greater Snows nest north of that area (Reed et al. 1998).

Southampton Island - While our air photo survey was being flown in June 1997, an independent visual aerial survey of muskoxen (*Ovibos moschatus*) and caribou (*Rangifer tarandus*) was being conducted by Robert Mulders (pers. comm.), Northwest Territories Renewable Resources. He flew a pattern of low-level parallel transect lines at 5 km intervals over all of Southampton and Coates islands and reported seeing no Snow Goose colony outside the ones which we documented with air photos.

West Hudson Bay – Habitats of the terrain west and north of this Region, with more rock outcrops and fewer vegetated lowlands, makes it unlikely that significantly large colonies exist outside the area covered in 1997 (see Kerbes 1982, Thompson et al. 1980). Historic records of nesting Snow Geese from this vast inland area have come only from a few locations on or near the Thelon River system. The closest to West Hudson Bay, approximately 260 km north west of Maguse River colony, was a small colony of 21 nesting pairs of Snow Geese recorded at Kazan Falls in 1970 (Miller 1972). McLaren and McLaren (1982) flew extensive surveys inland from West Hudson Bay, finding 75 and 139 pairs of nesting Snow Geese in 1975 and 1976, respectively, in the area between Pitz and Baker lakes. McCormick et al. (1990) recorded 235 Snow Geese in the Beverly and Aberdeen lakes area during an aerial survey of the Thelon River in July 1988, and they noted a few earlier records of Snow Geese from that area. Alexander (1990) flew another survey of the Thelon River in July 1989, recording 444 Snow Geese in the same area, including two colonies of 120 and 18 nesting pairs at the west end of Aberdeen Lake. Sirois and McCormick (1991) repeated the Thelon survey in July 1990, recording 658 Snow Geese, mainly in the west Aberdeen Lake area. Further waterfowl surveys in the interior of Nunavut west of Hudson Bay have not been done, so it is possible that the numbers of nesting Snow Geese may have increased at the above small colony sites, and other undocumented locations.

South Hudson Bay - The boreal forest lies adjacent to the coastal nesting habitats of Manitoba and Ontario. Given that the coastal area has been covered by near annual surveys (Abraham, unpubl.), it is unlikely that there were any undocumented light goose colonies in this region.

Central Arctic - There have been previous reports of small numbers of breeding Snow Geese in several areas which were not included in our 1998 survey (Fig. 3 and 36). McCormick (1989) estimated 8,000 to 9,000 nesting Snow Geese in 14 colonies in 1987-88 in the Pelly Lake area, on the Back River, about 50 km south of the QMGMBS. Bromley and Stenhouse (1994), in their post-hatch surveys of 1989-91, estimated there were almost 2,000 Snow Geese with about 50 broods in each of the Albert Edward Bay area and the south east area of Victoria Island, and about 1,000 Snow Geese with about 50 broods on King William Island. Hines et al. (2003) recorded 99 Snow Geese nesting at Snow Goose River on the south east coast of Rasmussen Basin in 1995. The habitat in all of the above areas is probably not suitable for significant expansion of nesting numbers. Nevertheless, growth may have occurred, and those areas, as well as the known and potential colony lakes of the QMGMBS should be covered in future inventories.

Other Arctic Regions? - As noted above, we assume that Snow Geese nesting in the region commonly referred to as the High Arctic, north of what we have defined as the Eastern and Central Arctic, are Greater Snow Geese. That population migrates through the arctic (Ungava) area of Quebec, as do some Lesser Snow Geese (Reed 1995). There are a few records of late summer broods and just one record of nesting Lesser Snow Geese in northern Quebec. On 7 June 2000 there were at least 4 nests (1 white pair, 1 mixed, 2 blue pairs) near the village of Aupaluk on the west side of Ungava Bay (A. Reed , pers. comm.).

4.5 Management Use of the 1997-1998 surveys

Our minimum estimate for the Mid-continent Snow Goose Population in 1997-98 (Eastern + Central Arctic) was 3,815,600 nesting adults, which was an over 3-fold increase from the total estimated for 1979-80 Eastern Arctic plus that of 1982 (the year of photo survey closest to 1979-80) for the Central Arctic. In the Central Arctic we estimated 740,600 nesting Snow Geese, which was an over 4-fold increase since the previous survey in 1988. Nesting Ross's Geese in 1997 totalled at least 542,800: 519,300 in the Central Arctic (an almost three-fold increase since 1988) and a minimum of 23,500 at McConnell River in the Eastern Arctic.

Our estimates for 1997-98 - a minimum of 3.8 million Mid-continent Snow Geese and more than half a million Ross's Geese, along with the estimates from previous periodic photo surveys - have been an important contribution to the conservation of these populations. Justification to take action to reduce the Mid-continent Snow Goose Population, for its own sustainability, for the health of associated arctic habitats and species, and for the benefit of consumptive and non-consumptive users, depended partly upon the results of our 1997-1998 survey. It provided a reliable index of population size and rate of recent increase. Management actions, such as increasing sport hunting bag limits and season lengths, were implemented in Canada and the United States in 1998-1999. The monitoring program for the Mid-continent Population includes evaluation of banding and

harvest information to assess changes in harvest and survival rates. As well, another photo survey to obtain updated estimates of nesting birds in the Mid-continent Population is underway. As planned (Batt 1997), the up-dated results will be compared to those of 1997-98 in evaluating the effectiveness of efforts to increase the harvest and other management measures applied to Mid-continent Snow Geese. The program is also relevant for the international management of Ross's Geese.

Ross's Geese, considered rare as recently as the 1940s (Hanson et al. 1956) have increased to the status of being considered overabundant (Alisauskas et al. 2006). While Mid-continent Snow Geese increased 3-fold in 17 years from 1979-80 to 1997, Ross's Geese increased 5-fold in 15 years from 1982 to 1998. The annual average rate of change for Snow Geese from 1979 to 1997 (18 years) on Baffin, Southampton and Cape Henrietta Maria was 7.3%, while the rate for Ross's Geese of the Central Arctic from 1988 to 1998 (10 years) was 10.7%. Of our 1997-98 estimated minimum 542,300 nesting Ross's Geese, most (96%) were in the Central Arctic. For the Eastern Arctic we have estimated a number only for McConnell River, with a minimum of 23,500 nesting birds. We have also cited evidence that Ross's Geese may have begun a rapid increase throughout their range in the Eastern Arctic.

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Table 1
Surveys of nesting Mid-continent Lesser Snow Geese and Ross's Geese showing dates, equipment and personnel

	Aerial photography					Ground survey			
Year and area	Biologist	Crew	Aircraft type	Camera	Photo dates	Biologist	Helicopter pilot	Helicopter type	Dates
1997 Baffin and Southampton islands	R. Kerbes[1]	A. Cilurso[2] K. Zberg[3] H. Forbes[3]	DH Twin Otter	Wild RC10	16-20 June	M. Wayland[1] (East Bay)	-	-	7,9 June
1997 West Hudson Bay and La Pérouse Bay	A. Didiuk[1]	R. Foster[2]	Partanavia	Zeis RMK	21-23 June	A. Didiuk[1] R. Bazin[1]	S. Miller	Bell 206B	26-29 June
1997 Cape Henrietta Maria	K. Abraham[4] K. Ross[1]	T. Senese[4] Larry Hill[4]	Navajo PA31-350	Wild RC10	14-19 June	K. Abraham[4] K.Ross[1] D.Fillman[1]	K. Mulcair	Bell 206L	2-3 June
1998 Central Arctic	R. Kerbes[1] K. Warner[1]	R. Foster[2]	Partanavia	Zeis RMK	18-23 June	R. Alisauskas[1] K. Warner[1]	M. Lemiuex	Bell 206L	15-22 June

[1] Canadian Wildlife Service; [2] US Fish & Wildlife Service; [3] Bradley Air Services; [4] Ontario Ministry of Natural Resources

Table 2
Candidate set of regression models for estimation of Lesser Snow and Ross's goose populations (N) from colony areas (A) in Queen Maud Gulf Migratory Bird Sanctuary.

Model	ΔAICc	Parameters estimated	AIC Weight
$N = \hat{\beta}_1(A) + \hat{\beta}_2(A^2)$	0.0000	3	0.4000
$N = \hat{\alpha} + \hat{\beta}(A)$	0.5852	3	0.2986
$N = \hat{\alpha} + \hat{\beta}_1(A) + \hat{\beta}_2(A^2)$	1.8703	4	0.1570
$N = \hat{\beta}(A)$	2.0383	2	0.1444

Table 3
Results of surveys of nesting Lesser Snow Geese in colonies of the eastern Canadian Arctic in 1997, with comparative results from 1979-1980, with ± 2 SE where feasible.

	1997						1979-1980[a]					
Colony	Nesting birds No.	±2 SE	Percent blue	Nesting area (km^2) with % analysed		Density (nesting ads/km^2)	Nesting birds No.	±2 SE	Percent blue	Nesting area (km^2) with % analysed		Density (nesting ads/km^2)
Baffin Island												
Prince Charles Island[b]	1 700	66%	-	9 552	3%	<1	-	-	-	-	-	-
Air Force Island[b]	17 300	23%	-	1 652	6%	10	-	-	-	-	-	-
Taverner Bay	469 300	30%	66.7%	364	10%	1289	-	-	-	-	-	-
Koukdjuak River[c]	450 100	31%	66.7%	2 110	5%	213	309 200[c]	37%[c]	60.7%[c]	-	-	-
Cape Dominion[c]	298 200	44%	80.3%	1 472	7%	203	[c]	[c]	[c]	-	-	-
Bowman Bay	452 200	36%	80.3%	619	12%	731	145 600	44%	70.3%	-	-	-
Cory Bay	42 500	51%	80.3%	66	24%	645	-	-	-	-	-	-
Garnet Bay	2 200	34%	80.3%	4	100%	512	-	-	-	-	-	-
Subtotal Baffin Island	1 733 500	17%		15 839	5%	109	454 800	29%		2930	-	155
Southampton Island												
Boas River	529 100	25%	24.8%	1735	6%	305	175 200	18%	23.0%	540	-	324
W. Boas River	-	-	-	-	-		5 800	76%	36.4%	40	-	145
Ell Bay	22 600	83%	24.8%	140	9%	162	5 200	35%	28.8%	38	-	137
Bear Cove	11 800	29%	24.8%	51	3%	230	4 200	52%	39.0%	36	-	117
Sutton River	931	16%	24.8%	5	4%	198	-	-	-	-	-	-
Coral Harbour	11 900	47%	45.2%	157	13%	76	-	-	-	-	-	-
East Bay	144 800	27%	45.2%	634	6%	228	42 600	37%	45.6%	344	-	124
Subtotal Southampton Is.	721 200	20%		2721	6%	265	233 000	15%		998	-	233
West Hudson Bay												
Maguse River	80 900	23%	24.6%	151	14%	534	14 300	23%	18.5%	105	29%	136
Wolf Creek	4 400	26%	24.6%	90	34%	49	51 800	14%	18.5%	104	25%	498
McConnell River[d]	65 500	10%	24.6%	228	64%	287	230 800	8%	20.3%	276	20%	836
South McConnell	26 800	14%	24.6%	148	51%	181	17 600	23%	20.3%	98	12%	180
Tha-anne River	34	6%	24.6%	1	100%	37	2 900	3%	20.3%	1	100%	2 900
Geillini River	34 000	24%	24.6%	142	15%	240	-	-	-	-	-	-
Subtotal W. Hudson Bay	211 600	10%		759	39%	279	317 400	6%		584	21%	543
South Hudson Bay												
Knife River	4 700	9%	35.6%	22	78%	207	908	0%	5.3%	7	100%	130
La Pérouse Bay	58 700	20%	35.6%	110	33%	536	8 800	9%	27.0%	9	-	978
West Pen Island	16 500	22%	64.6%	7	5%	2302	-	-	-	-	-	-
Shell Brook	5 300	35%	64.6%	7	31%	781	-	-	-	-	-	-
Cape Henrietta Maria[e]	320 000	15%	64.6%	277	4%	1155	109 200	10%	71.1%	79	25%	687
Akimiski Island[f]	3 400	-	74.6%	-	-	-	-	-	-	-	-	-
Subtotal S. Hudson Bay	408 700						118 908	9%				
E. Arctic total	3 075 000						1 124 108	14%				

[a] Baffin and Southampton islands 1979 from Reed et al 1987; La Pérouse Bay 1979 from Cooke et al 1983; Cape Henrietta Maria 1979 from Angehrn 1979; West Hudson Bay 1980 from Kerbes et al 1990; Knife River 1978 total count from Kerbes unpubl.

[b] Prince Charles Island and Air Force Island visual survey from helicopter; entire islands treated as nesting areas; percent blue not taken (S. Pepper and V. Johnston, unpubl.)

[c] Koukdjuak River and Cape Dominion combined in 1979 by Reed et al (1987)

[d] McConnell River had 23 476 nesting Ross's Geese, as total count from high density areas (see text section 4.1.3.1)

[e] Cape Henrietta Maria 1997 helicopter transect survey (Abraham et al. 1998)

[f] Akimiski Island 1997 ground survey by Abraham et al (1999)

Table 4
Estimated number of Lesser Snow Geese (with percent blue morph) and Ross's Geese nesting in the Central Canadian Arctic, June 1998, with ±2 SE where feasible.

Queen Maud Gulf Migratory Bird Sanctuary area [a]

Colony	Snow No.	±2 SE	% blue	Ross's No.	±2 SE	Total	±2 SE
3[b],51,65 [c]	257 192	18%	15.3%	179 645	20%	436 837	16%
9,36 [c]	26 682	40%	26.2%	9 383	47%	36 065	37%
10 [c]	228 747	21%	22.6%	250 787	20%	479 534	15%
12 [d]	158	6%	20.5%	107	10%	265	1%
13 [d]	747	6%	20.5%	504	10%	1 251	1%
14 [d]	34	6%	20.5%	23	9%	57	2%
15 [c]	8 766	19%	20.5%	5 917	20%	14 683	18%
18 [c]	2 436	19%	26.1%	113	125%	2 549	18%
19 [d]	771	6%	20.5%	520	9%	1 291	1%
29 [c]	1 123	25%	20.5%	758	26%	1 881	25%
30 [d]	29	5%	20.5%	19	11%	48	1%
41 [d]	22	7%	20.5%	15	10%	37	1%
42 [c]	30	57%	20.5%	20	55%	50	56%
46,27,45 [c]	45 864	20%	20.2%	23 642	32%	69 506	14%
88 [c]	9 987	32%	28.6%	2 389	70%	12 376	29%
Total	582 588	12%	19.4%	473 842	13%	1 056 430	10%
All others [e]	69 161		16.3%	21 244		90 405	
QMG Total	651 749		18.6%	495 086		1 146 835	

Central Arctic colonies outside Queen Maud Gulf MBS area [a]

Adelaide Pen. 1 [f]	119			81		200	
Adelaide Pen. 2 [c]	7 570	25%	20.5%	5 110	26%	12 680	24%
Elliot Bay [c]	27 380	26%	20.5%	18 481	27%	45 861	26%
Jenny Lind Is.[g, c]	18 729	24%	19.6%	524	81%	19 253	24%
Inglis River[h, c]	30 735	24%	21.8%	-		30 735	24%
Kuuguarjuk Lake[h, d]	4 308	8%	27.1%	-		4 308	8%
outside QMG Total [i]	88 841	13%	21.1%	24 196	22%	113 037	13%
Total Central Arctic colonies	740 590		18.9%	519 282		1 259 872	

[a] See text for details on colour morph and species ratios
[b] Karrak Lake
[c] From samples of aerial photographs
[d] Total colony counted from aerial photographs
[e] 53 colonies with number of nesting birds visually estimated from helicopter or photo aircraft, or estimated by extrapolation
[f] Visual estimate from photo aircraft
[g] Used species and colour phase ratios from 1988
[h] Ross's presence unknown, totals assume insignificant number of Ross's
[i] Confidence limits exclude Adelaide Pen. 1

Table 5
Estimated combined number of nesting Lesser Snow and Ross's geese (with percent Ross's) in June, Central Canadian Arctic, 1965-1967 (from Ryder 1969, 1971), 1976, 1982, 1988 (from Kerbes 1994) and 1998. See Fig. 36 for colony locations.

	1965-67		1976		1982		1988		1998	
Colony	No. nesting birds	(%Ross's)	No. nesting birds	(%Ross's)	No. nesting birds	(%Ross's)	No. nesting birds	(%Ross's)	No. nesting birds	(%Ross's)
1	12	(100)	569	(58)	203	(50)	897	(75)	730 [a]	(42)
2	2 000	(75)	5 667	(78)	4 938	(51)	5 591	(44)	3 610 [b]	(53)
3	17 060	(70)	54 537	(60)	105 583	(52)	212 820	(33)	436 837 [c]	(41)
4	180	(17)	0		92	(0)	407	(48)	280 [a]	(42)
5	100	(60)	0		0		2	(0)	0	
6	230	(87)	0		388	(64)	706	(41)	720 [a]	(42)
7	54	(93)	0		0		0		13 [a]	(42)
8	3 800	(68)	4 172	(39)	835	(62)	2 692	(42)	1876 [a]	(42)
9	6 200	(97)	15 082	(24)	36 393	(30)	75 209	(29)	36 065 [c]	(26)
10	5 600	(89)	27 115	(77)	34 381	(47)	111 807	(65)	479 534 [c]	(52)
11	40	(100)	0		35	(63)	0		38 [a]	(42)
12	85	(71)	38	(58)	0		23	(41)	265 [c]	(40)
13	360	(83)	428	(58)	464	(36)	59	(41)	1 251 [c]	(40)
14	60	(100)	418	(58)	19	(100)	67	(41)	57 [c]	(40)
15	1 500	(80)	1 497	(47)	681	(14)	6 580	(41)	14 683 [c]	(40)
16	40	(100)	0		37	(5)	123	(41)	92 [a]	(42)
17	30	(67)	626	(58)	34	(0)	212	(41)	700 [a]	(42)
18	200	(100)	1 256	(58)	2 810	(9)	6 637	(8)	2 549 [c]	(4)
19	450	(83)	427	(58)	9	(100)	902	(41)	1 291 [c]	(40)
20	50	(100)	534	(58)	80	(43)	172	(48)	- [d]	
21	190	(74)	28	(58)	554	(0)	16	(50)	324 [a]	(42)
22	125	(80)	0		0		0		540 [a]	(42)
23	[e]		826	(58)	594	(53)	2 115	(48)	750 [a]	(42)
24	[e]		164	(58)	258	(43)	432	(48)	260 [a]	(42)
25	[e]		213	(58)	126	(0)	366	(48)	376 [a]	(42)
26	[e]		0		12	(42)	0		68 [a]	(42)
27	[e]		4 760	(38)	828	(64)	1 521	(41)	in Col. 46 [f]	
28	[e]		0		0		178	(41)	- [d]	
29	[e]		7 324	(64)	1 284	(51)	1 085	(41)	1 881 [c]	(40)
30	[e]		593	(58)	254	(0)	383	(41)	48 [c]	(41)
31	[e]		0		88	(64)	127	(41)	48 [a]	(42)
32	[e]		0		16	(63)	0		300 [a]	(42)
33	[e]		0		0		0		0	
34	[e]		107	(58)	58	(64)	2	(0)	220 [a]	(42)
35	[e]		427	(58)	0		0		500 [a]	(42)
36	150	(38)	4 241	(47)	1 334	(55)	5 224	(63)	in Col. 9 [f]	
37	80	(40)	142	(58)	247	(0)	2	(0)	60 [a]	(42)
38	[h]		427	(58)	196	(48)	0 [k]		0	
39	[h]		51	(58)	127	(27)	95	(48)	232 [a]	(42)
40	[h]		1 519	(0)	98	(0)	765	(48)	100 [a]	(42)
41	[h]		295	(58)	0		0		37 [c]	(40)
42	[h]		213	(58)	40	(0)	67	(41)	50 [c]	(41)
43	[h]		[h]		102	(64)	28	(41)	500 [a]	(42)
44	[h]		[h]		37	(43)	491	(48)	80 [a]	(42)
45	[h]		[h]		306	(64)	523	(41)	in Col. 46 [f]	
46	[h]		[h]		2 553	(64)	22 736	(18)	69 506 [c]	(34)
47	[h]		[h]		123	(63)	17	(41)	0	
48	[h]		[h]		133	(63)	429	(41)	620 [a]	(42)

Table 5 continued

Colony	1965-67 No. nesting birds (%Ross's)	1976 No. nesting birds (%Ross's)	1982 No. nesting birds (%Ross's)	1988 No. nesting birds (%Ross's)	1998 No. nesting birds (%Ross's)
49	[h]	[h]	120 (64)	37 (41)	0
50	[h]	[h]	[h]	1 003 (41)	35 [a] (42)
51	[h]	[h]	[h]	683 (41)	in Col. 3 [f]
52	[h]	[h]	[h]	68 (41)	0
53	[h]	[h]	[h]	32 (41)	0
54	[h]	[h]	[h]	261 (41)	0
55	[h]	[h]	[h]	492 (41)	240 [a] (42)
56	[h]	[h]	[h]	235 (41)	0
57	[h]	[h]	[h]	541 (41)	890 [a] (42)
58	[h]	[h]	[h]	141 (41)	360 [a] (42)
59	[h]	[h]	[h]	54 (41)	4 [a] (42)
60	[h]	[h]	[h]	301 (41)	0
61	[h]	[h]	[h]	441 (41)	0
62	[h]	[h]	[h]	416 (41)	400 [a] (42)
63	[h]	[h]	[h]	257 (41)	615 [a] (42)
64	[h]	[h]	[h]	14 (41)	0
65	[h]	[h]	[h]	148 (41)	in Col. 3 [f]
66	[h]	[h]	[h]	342 (41)	0
67 [i]	[h]	[h]	[h]	[h]	0
68 [i]	[h]	[h]	[h]	[h]	52 263 [l] (7)
69 [i]	[h]	[h]	[h]	[h]	0
70 [i]	[h]	[h]	[h]	[h]	0
71 [i]	[h]	[h]	[h]	[h]	130 [a] (42)
72 [i]	[h]	[h]	[h]	[h]	0
73 [i]	[h]	[h]	[h]	[h]	140 [a] (42)
74 [i]	[h]	[h]	[h]	[h]	- [d]
75 [i]	[h]	[h]	[h]	[h]	- [d]
76 [i]	[h]	[h]	[h]	[h]	in Col. 68 [f]
77 [i]	[h]	[h]	[h]	[h]	- [d]
78 [i]	[h]	[h]	[h]	[h]	0
79 [i]	[h]	[h]	[h]	[h]	2 [a] (42)
80 [i]	[h]	[h]	[h]	[h]	460 [a] (42)
81 [i]	[h]	[h]	[h]	[h]	3 654 [l] (74)
82 [i]	[h]	[h]	[h]	[h]	0
83 [i]	[h]	[h]	[h]	[h]	0 [k]
84 [i]	[h]	[h]	[h]	[h]	170 [a] (42)
85 [i]	[h]	[h]	[h]	[h]	20 [a] (42)
86 [i]	[h]	[h]	[h]	[h]	13 975 [l] (42)
87 [i]	[h]	[h]	[h]	[h]	0
88 [i]	[h]	[h]	[h]	[h]	12 376 [c] (19)
89 [i]	[h]	[h]	[h]	[h]	- [d]
90 [i]	[h]	[h]	[h]	[h]	0
91 [i]	[h]	[h]	[h]	[h]	570 [a] (42)
92 [i]	[h]	[h]	[h]	[h]	0
93	[h]	[h]	[h]	[h]	220 [a] (42)
94	[h]	[h]	[h]	[h]	10 [a] (42)
95	[h]	[h]	[h]	[h]	10 [a] (42)
96	[h]	[h]	[h]	[h]	660 [a] (42)

Table 5 continued

Colony	1965-67 No. nesting birds (%Ross's)		1976 No. nesting birds (%Ross's)		1982 No. nesting birds (%Ross's)		1988 No. nesting birds (%Ross's)		1998 No. nesting birds (%Ross's)	
97	[h]		[h]		[h]		[h]		460 [a]	(42)
98	[h]		[h]		[h]		[h]		300 [a]	(42)
99	[h]		[h]		[h]		[h]		300 [a]	(42)
100	[h]		[h]		[h]		[h]		220 [a]	(42)
101	[h]		[h]		[h]		[h]		1 000 [a]	(42)
102	[h]		[h]		[h]		[h]		260 [a]	(42)
Subtotal QMG MBS	44 300[k]	(77)	133 696	(58)	196 470	(46)	466 975	(40)	1146833	(43)
Jenny Lind Is.	[g]		[g]		[g]		39 200	(3)	19 253 [c]	(3)[l]
Adelaide Pen. 1	[h]		[h]		[h]		[h]		200 [a]	(40)
Adelaide Pen. 2	[h]		[h]		[h]		[h]		12 680 [c]	(40)
Elliot Bay	[h]		[h]		[g]		[g]		45 861 [c]	(40)
Inglis River	[h]		[g]		[g]		[g]		30 735 [c]	
Kuuguarjuk Lake	[h]		[h]		[h]		[h]		4 308 [c]	
Subtotal N & E of QMG MBS							39 200	(3)	113 037	(21)
Total	44 300[m]	(77)	133 696	(58)	196 470	(46)	506 174	(37)	1 259 870	(41)

[a] Visual estimate
[b] Calculated average (see text 2.4)
[c] estimated from aerial photographs
[d] Not visited in 1998
[e] Geese known to be present (Ryder 1969)
[f] Merged with another colony
[g] Nesting geese known to be present (see text)
[h] Status unknown, likely unoccupied
[i] Nesting geese known to be present in 1990 and/or 1991 (Alisauskas and Boyd 1994)
[j] Calculated estimate using density-area regression (see text 2.4)
[k] Lake had drained from natural causes since previous survey
[l] Percent Ross's and percent blue of Snow Geese assumed as in 1988
[m] Total as extrapolated in Kerbes et al (1983)

Table 6
Summary of survey estimates of Lesser Snow and Ross's geese nesting in the Queen Maud Gulf Migratory Bird Sanctuary, 1965-1998.

	1965-67	1976	1982	1988	1998
No. of occupied colonies[1]	37	30	41	57	73
Total no. of nesting birds (Ross's plus Snows)	44 300	133 700	196 500	467 000	1 146 800
Total no. of nesting Ross's Geese	34 000	77 300	90 800	188 000	495 100
(Percentage of total geese)	(77%)	(58%)	(46%)	(40%)	(43%)
Total no. of nesting Snow Geese	10 300	56 400	105 700	279 000	651 700
Percentage of blue-morph among Snow Geese	5.0%	14.9%	8.0%	19.6%	18.6%
Percentage of total nesting geese per colony					
Colony 3	39	41	54	46	38[2]
Colony 9	14	11	19[3]	16[3]	3[3]
Colony 10	13	20	17	24	42
Colony 46	0	0	1	5	6[4]
All other colonies	34	28	9	9	11
	100	100	100	100	100

[1] Includes colonies which have merged with others
[2] Includes Colonies 51 and 65
[3] Includes Colony 36
[4] Includes Colonies 27 and 45

Table 7
Persistence of Lesser Snow and Ross's goose colonies, 1965 to 1998 in Queen Maud Gulf Migratory Bird Sanctuary (see Fig. 36 for locations)

Colony	Colony presence by year[1]					
	1965-67[2]	1976[3]	1982[3]	1988[3]	1990-91[4]	1998
1	+	+	+	+	+	+
2	+	+	+	+	+	+
3	+	+	+	+	+	+
4	+	-	+	+	-	+
5	+	-	-	+	-	-
6	+	-	+	+	-	+
7	+	-	-	-	-	+
8	+	+	+	+		+
9	+	+	+	+		+
10	+	+	+	+	+	+
11	+	-	+	-		+
12	+	+	-	+		+
13	+	+	+	+		+
14	+	+	+	+		+
15	+	+	+	+		+
16	+	-	+	+		+
17	+	+	+	+		+
18	+	+	+	+		+
19	+	+	+	+		+
20	+	+	+	+		
21	+	+	+	+		+
22	+	-	-	-		+
23	+	+	+	+		+
24	+	+	+	+		+
25	+	+	+	+	+	+
26	+	-	+	-		+
27	+	+	+	+	+	+
28	+	-	-	+	-	
29	+	+	+	+		+
30	+	+	+	+	-	+
31	+	-	+	+		+
32	+	-	+	-		+
33	+	-	-	-		-
34	+	+	+	+		+
35	+	+	-	-		+
36	+	+	+	+		+
37	+	+	+	+		+
38		+	+	-		-
39		+	+	+		+
40		+	+	+		+
41		+	-	-		+
42		+	+	+		+
43			+	+		+
44			+	+	+	+
45			+	+		+
46			+	+		+
47			+	+		-
48			+	+		+
49			+	+	+	-
50				+		+
51				+		+

Colony	Colony presence by year[1]					
	1965-67[2]	1976[3]	1982[3]	1988[3]	1990-91[4]	1998
52				+		-
53				+		-
54				+		-
55				+		+
56				+	-	-
57				+		+
58				+		+
59				+		+
60				+	+	-
61				+		-
62				+	+	+
63				+		+
64				+		-
65				+		+
66				+	+	-
67					+	-
68					+	+
69					+	-
70					+	-
71					+	+
72					+	-
73					+	+
74					+	
75					+	
76					+	+
77					+	
78					+	-
79					+	+
80					+	+
81					+	+
82					+	-
83					+	-
84					+	+
85					+	+
86					+	+
87					+	-
88					+	+
89					+	
90					+	-
91					+	+
92					+	-
93						+
94						+
95						+
96						+
97						+
98						+
99						+
100						+
101						+
102						+

[1] + = colony site occupied; - = colony site not occupied

[2] Ryder 1969

[3] Kerbes 1994

[4] Alisauskas and Boyd 1994

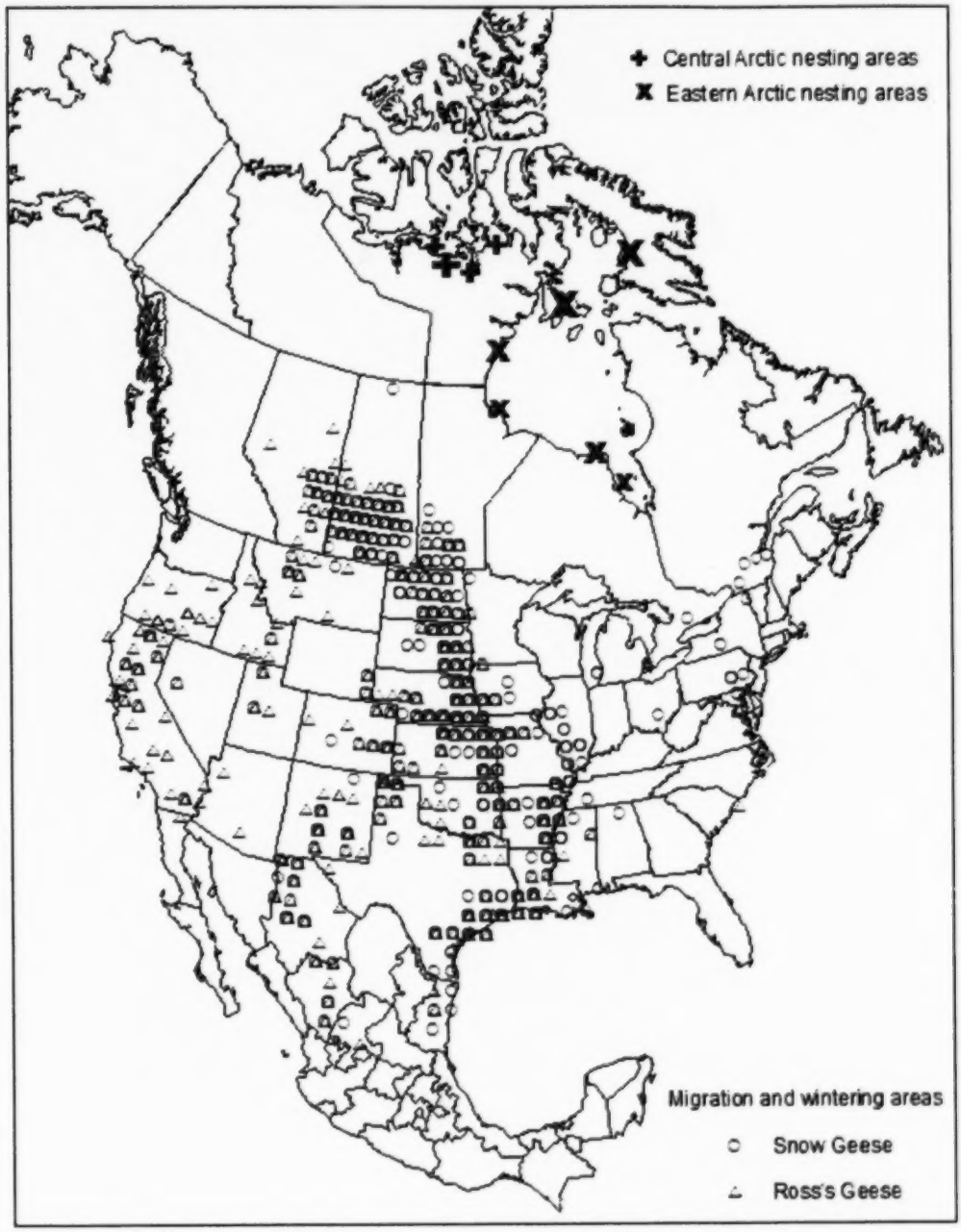

Figure 1
Nesting, migration and wintering areas of the Mid-continent Lesser Snow Goose Population and Ross's Geese (migration and wintering distribution from neckband observations, 1987-2005, Meeres, unpubl.)

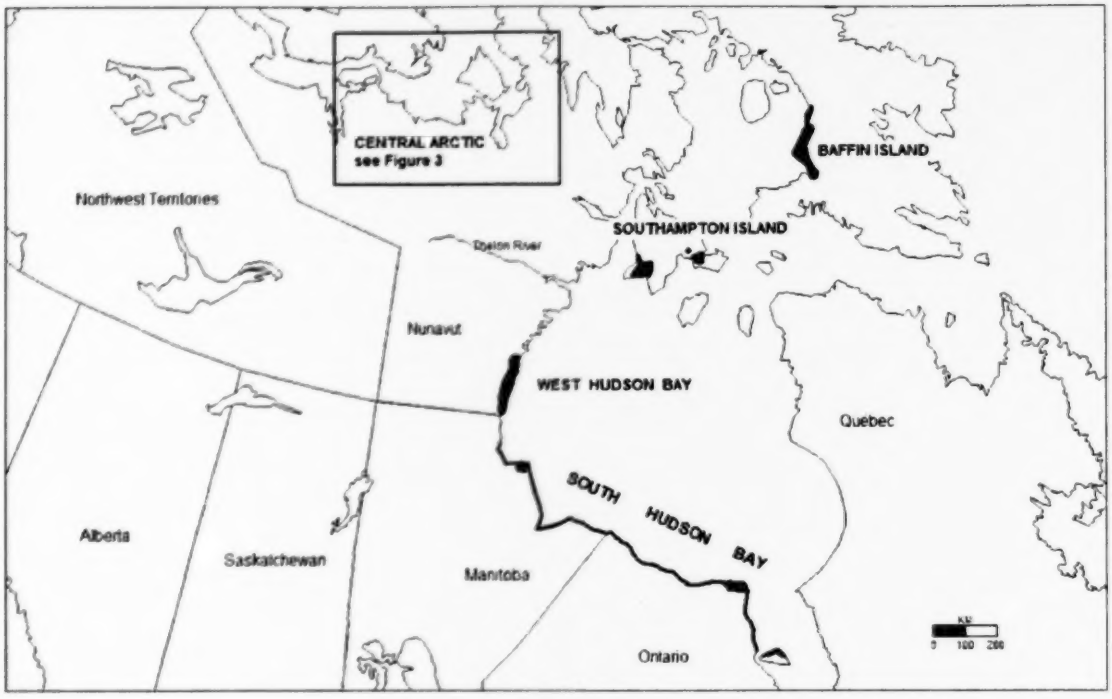

Figure 2
Nesting range of Lesser Snow and Ross's Geese of the Eastern and Central Canadian Arctic, showing major nesting regions

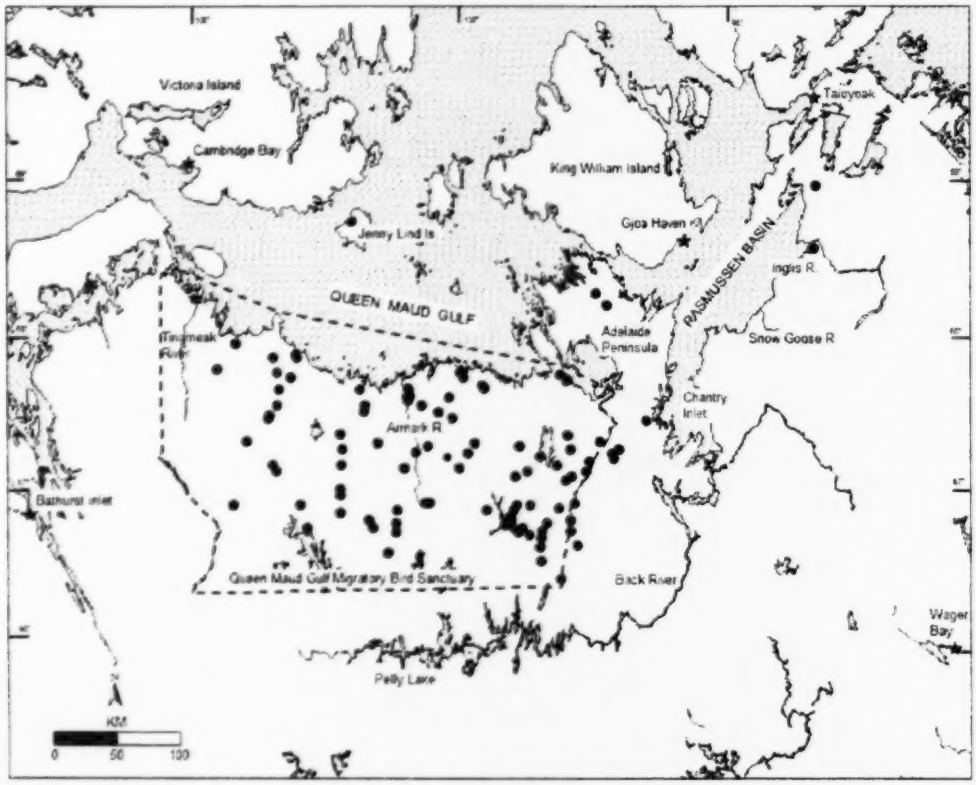

Figure 3
Colonies of Ross's Geese and Lesser Snow Geese in the Central Canadian Arctic, Nunavut. See Figure 2 for relationship to Eastern Arctic, and Figure 36 for more detail.

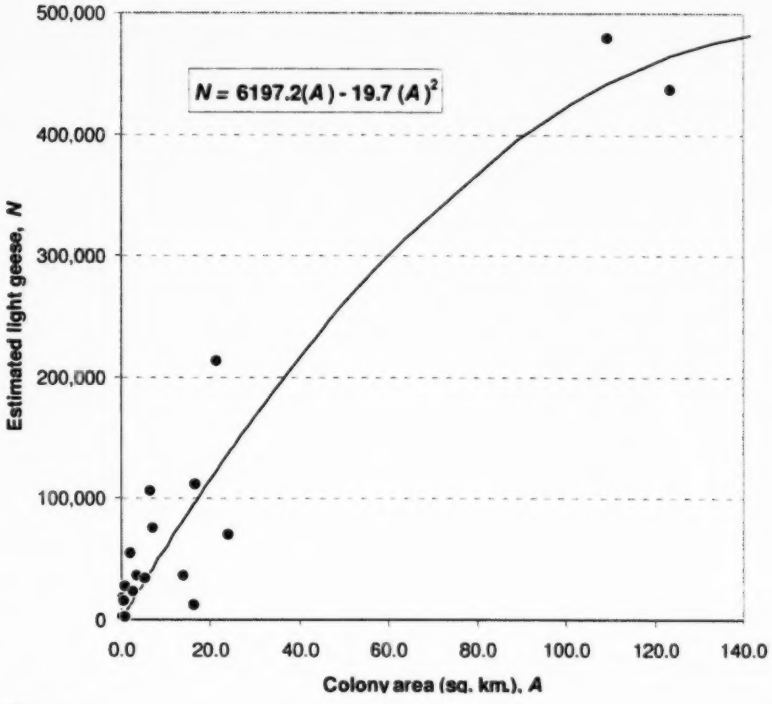

Figure 4
Regression of numbers of nesting Ross's and Lesser Snow geese estimated from photo surveys (Kerbes 1994) against their respective areas occupied

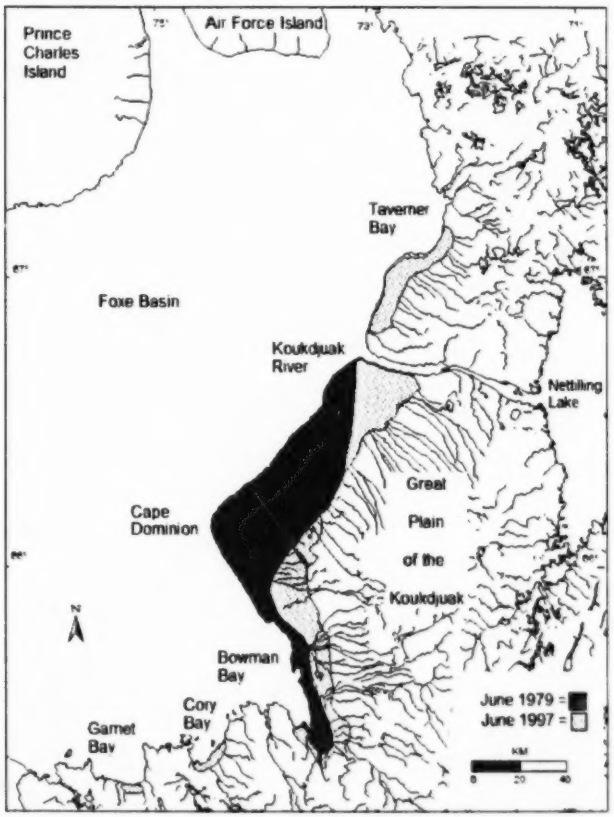

Figure 5
Baffin Island Lesser Snow Goose colonies, showing area occupied by nests in 1979, with expansion recorded in 1997

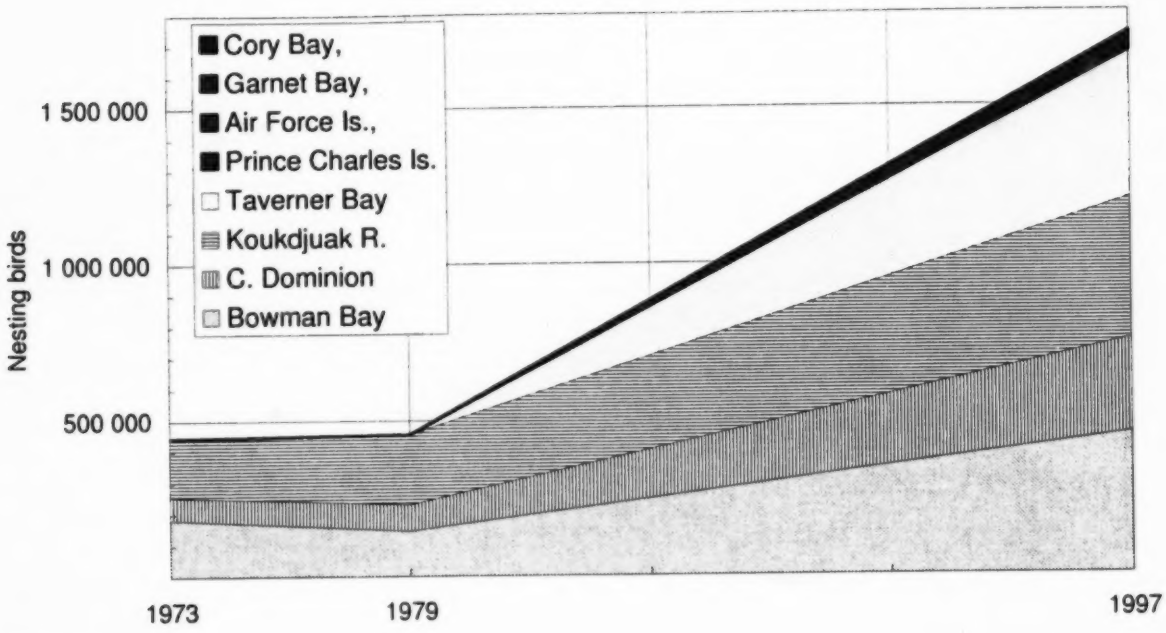

Figure 6
Growth in numbers of nesting birds by colony of Lesser Snow Geese, Baffin Island, 1973-1997

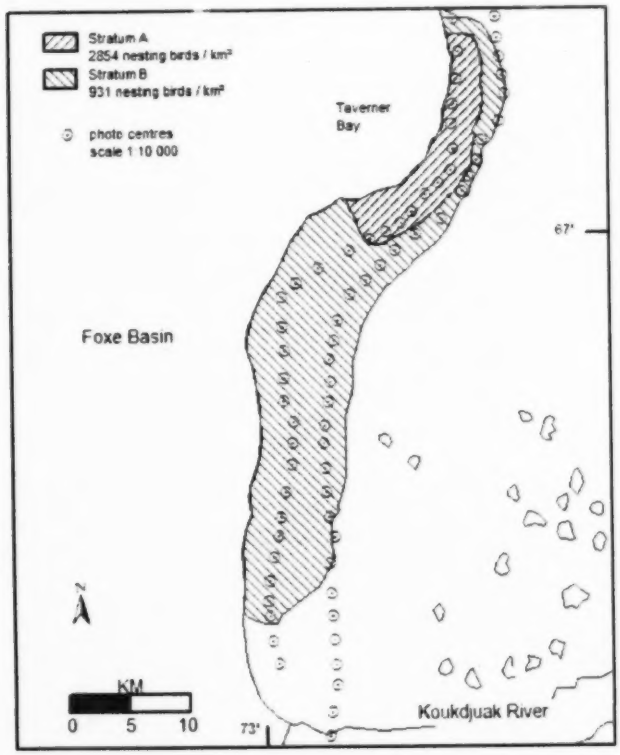

Figure 7
Lesser Snow Goose colony at Taverner Bay, Nunavut, showing the area occupied by nests, June, 1997

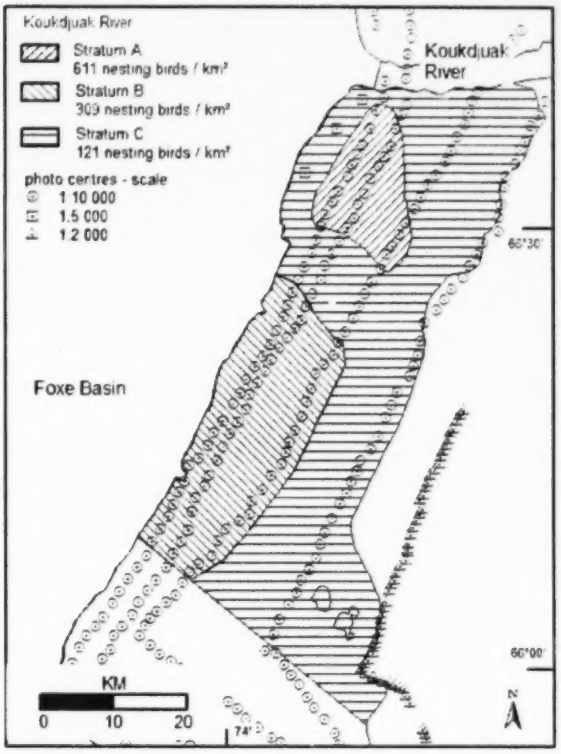

Figure 8
Lesser Snow Goose colony at Koukdjuak River, Nunavut, showing the area occupied by nests, June, 1997

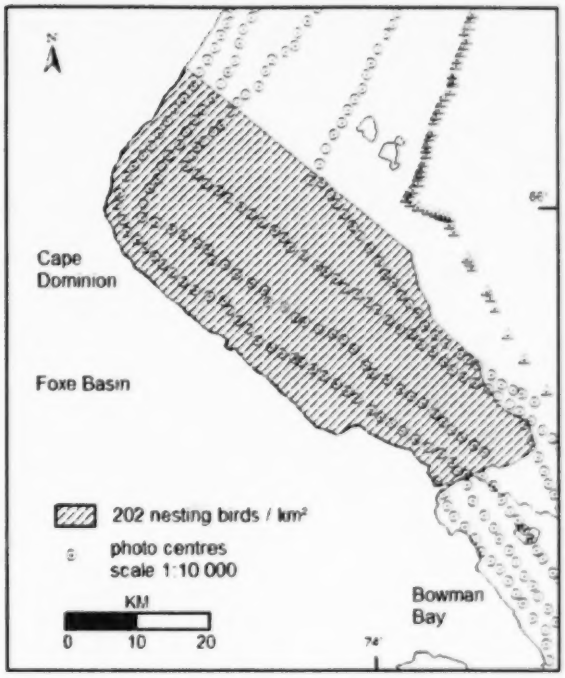

Figure 9
Lesser Snow Goose colony at Cape Dominion, Nunavut, showing the area occupied by nests, June, 1997

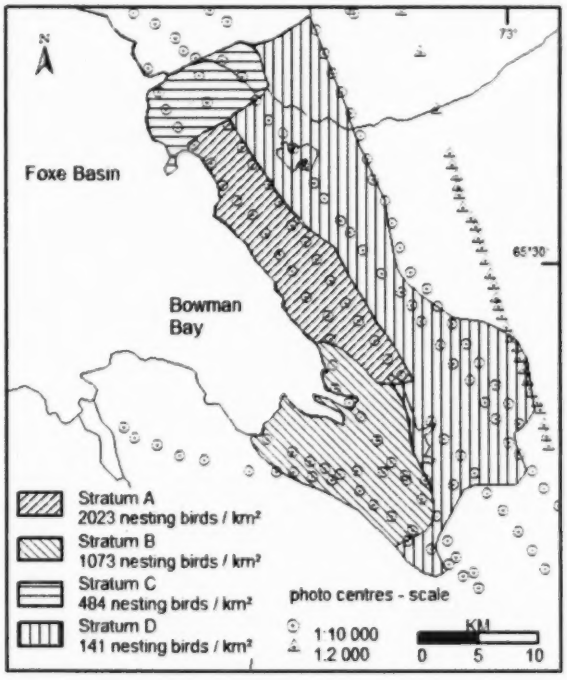

Figure 10
Lesser Snow Goose colony at Bowman Bay, Nunavut, showing the area occupied by nests, June, 1997

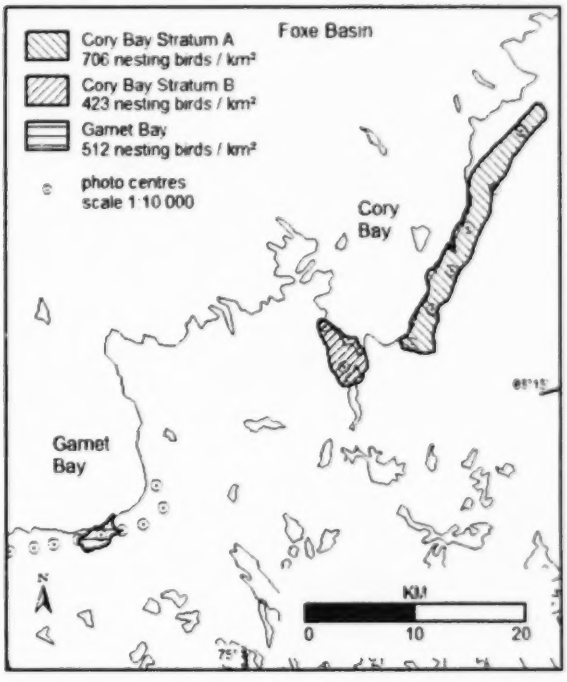

Figure 11
Lesser Snow Goose colonies at Cory Bay and Garnet Bay, Nunavut, showing the area occupied by nests, June, 1997

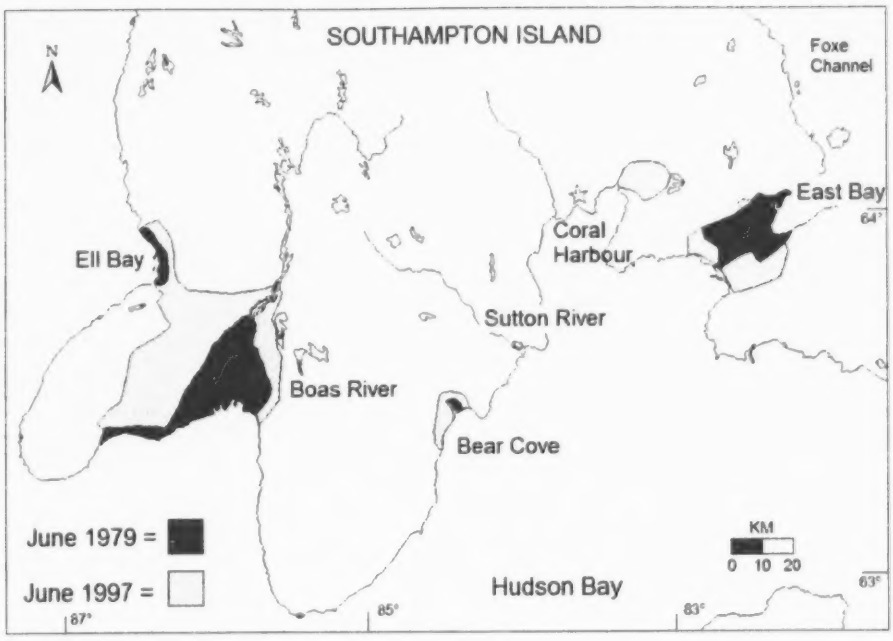

Figure 12
Southampton Island Lesser Snow Goose colonies, showing area occupied by nests in 1979, with expansion recorded in 1997

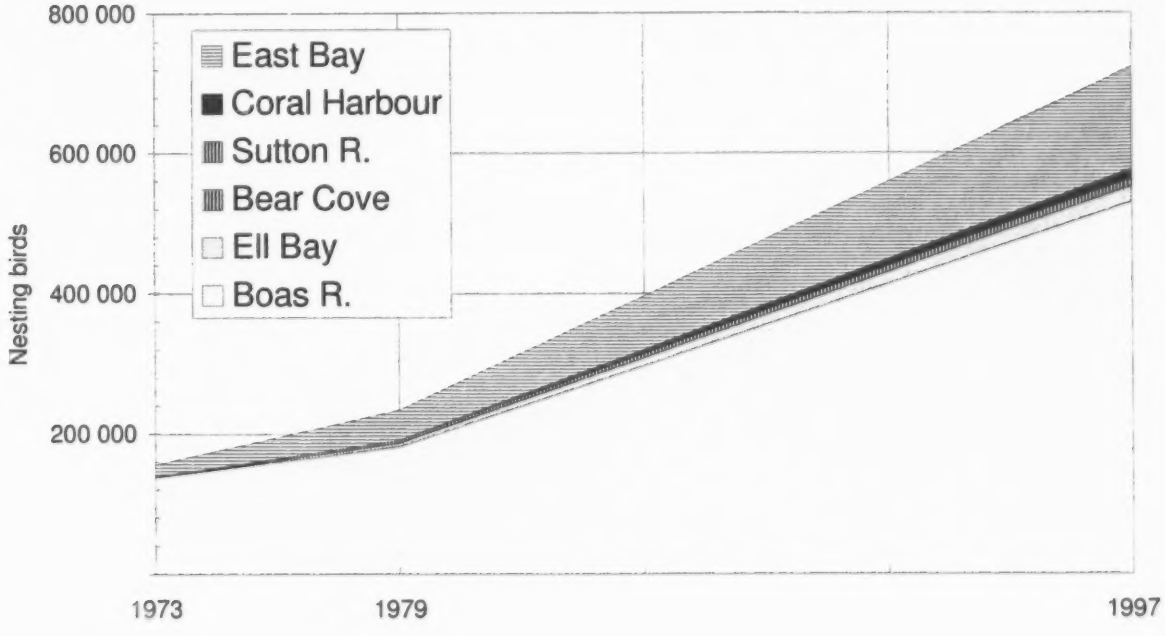

Figure 13
Growth in numbers of nesting birds by colony of Lesser Snow Geese, Southampton Island , 1973-1997

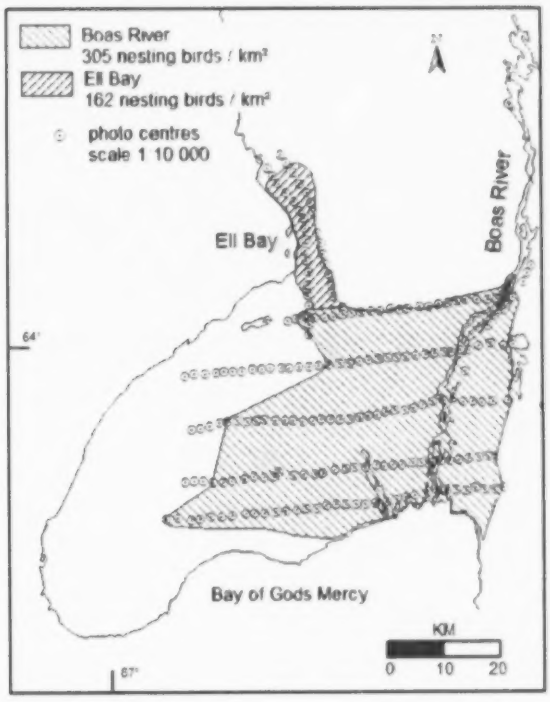

Figure 14
Lesser Snow Goose colonies at Boas River and Ell Bay, Nunavut, showing the area occupied by nests, June, 1997

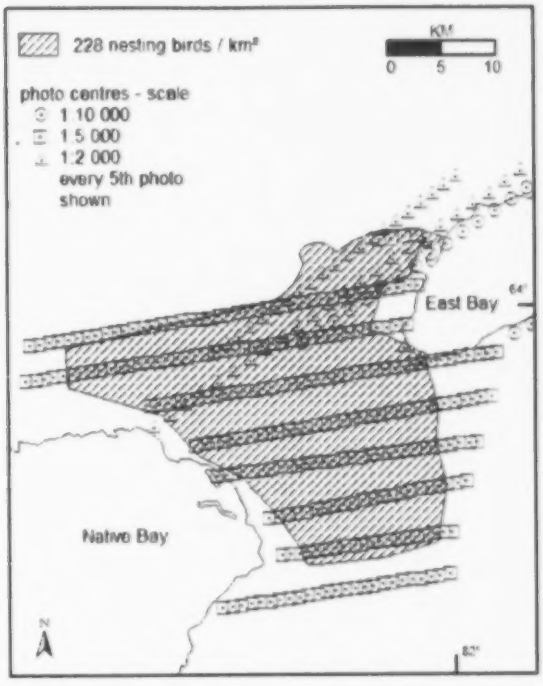

Figure 15
Lesser Snow Goose colony at East Bay, Nunavut, showing the area occupied by nests, June, 1997

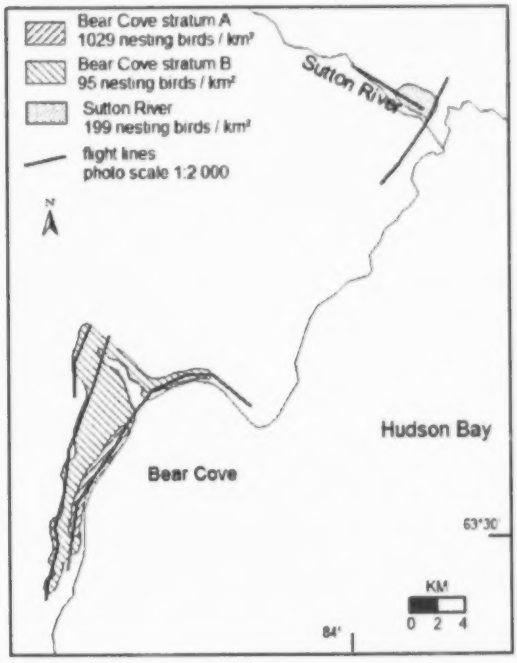

Figure 16
Lesser Snow Goose colonies at Bear Cove and Sutton River, Nunavut, showing the area occupied by nests, June, 1997

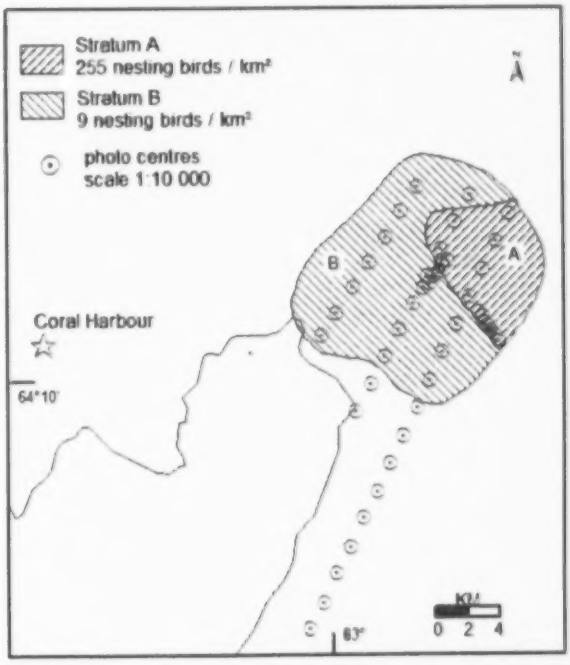

Figure 17
Lesser Snow Goose colony at Coral Harbour, Nunavut, showing the area occupied by nests, June, 1997

Figure 18
West Hudson Bay Lesser Snow Goose colonies, showing area occupied by nests in June 1985 and June 1997

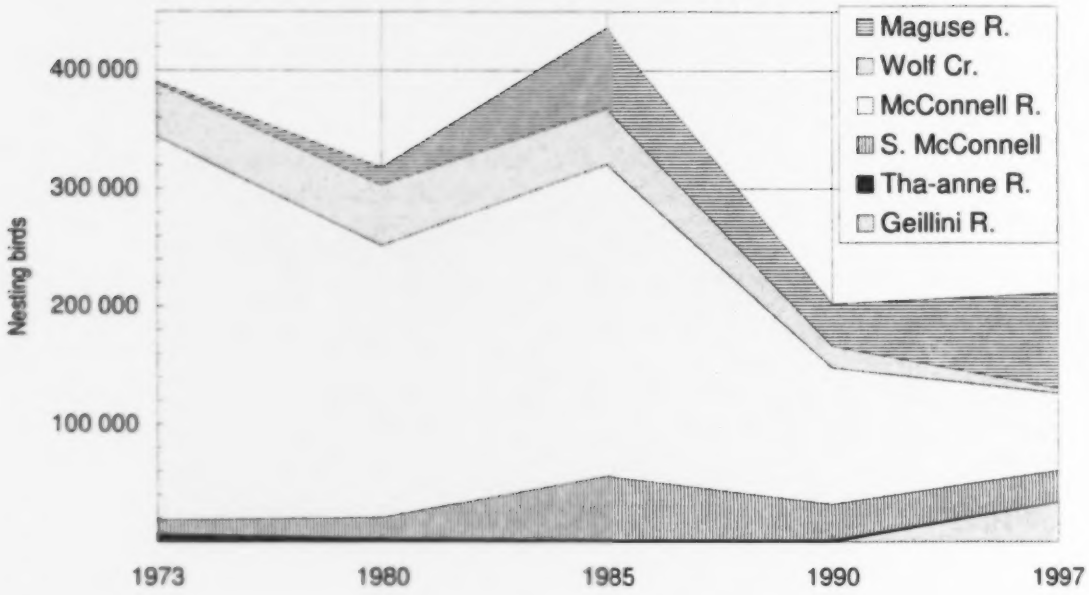

Figure 19
Growth in numbers of nesting birds by colony of Lesser Snow Geese, West Hudson Bay, 1973-1997

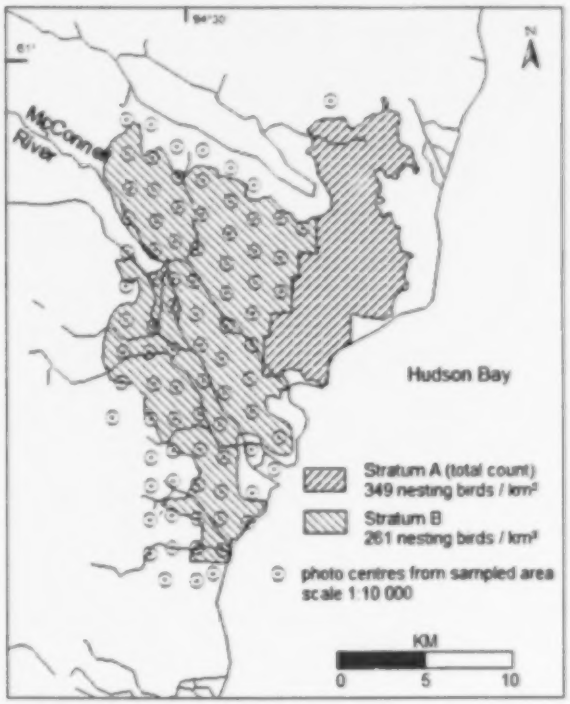

Figure 20
Lesser Snow Goose colony at McConnell River, Nunavut, showing the area occupied by nests, June 1997. See Figure 25 for Ross's Goose nesting pockets within Stratum A.

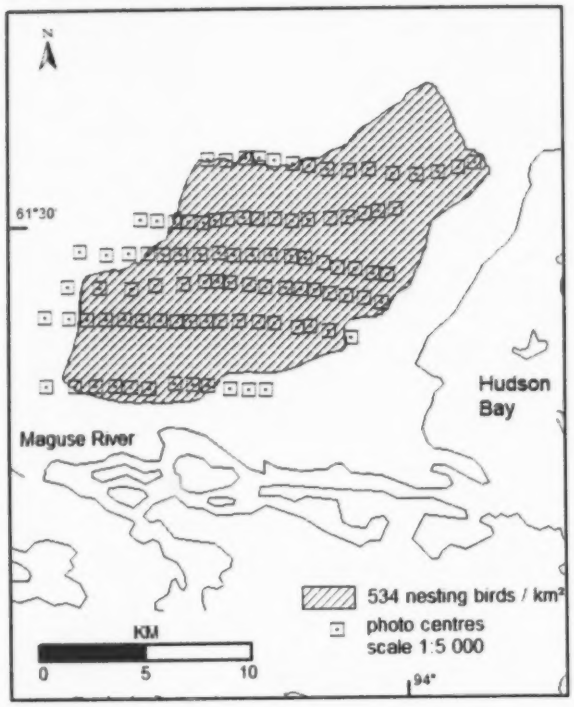

Figure 21
Lesser Snow Goose colony at Maguse River, Nunavut, showing the area occupied by nests, June, 1997

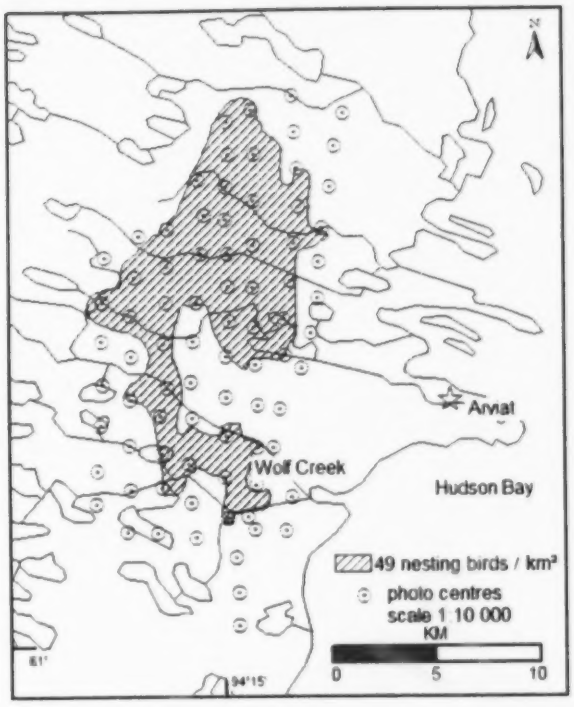

Figure 22
Lesser Snow Goose colony at Wolf Creek, Nunavut, showing the area occupied by nests, June, 1997

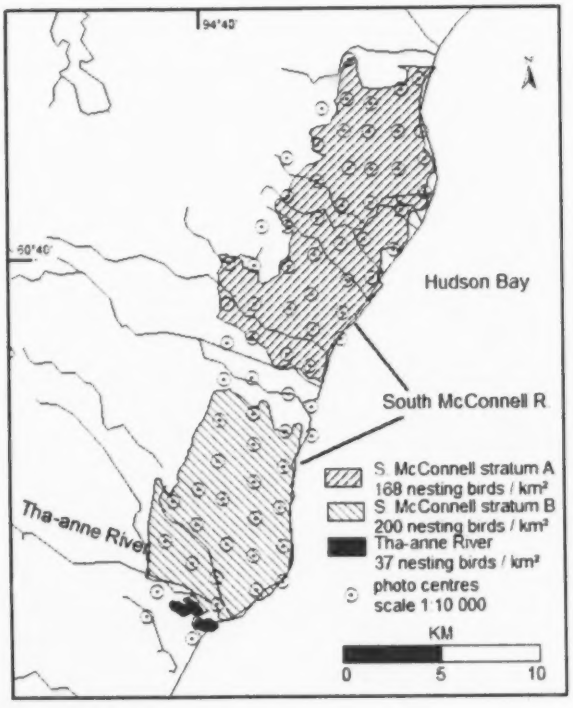

Figure 23
Lesser Snow Goose colonies at South McConnell River and Tha-anne River, Nunavut, showing the area occupied by nests, June, 1997

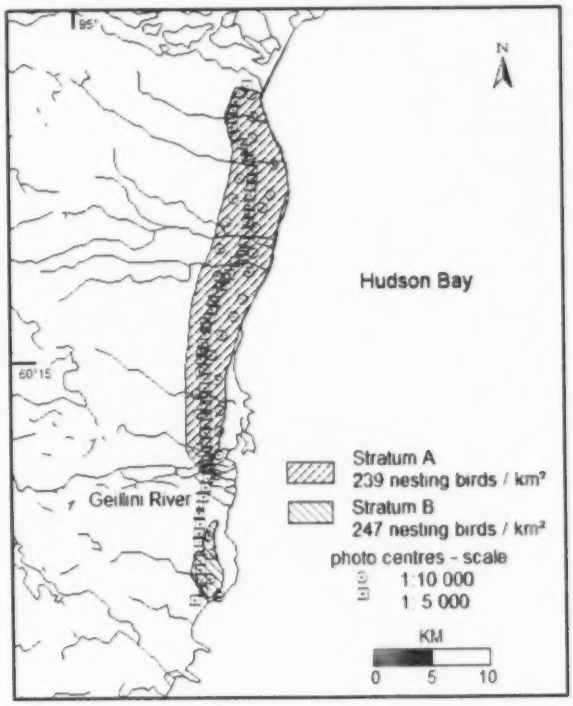

Figure 24
Lesser Snow Goose colony at Geillini River, Nunavut, showing the area occupied by nests, June, 1997

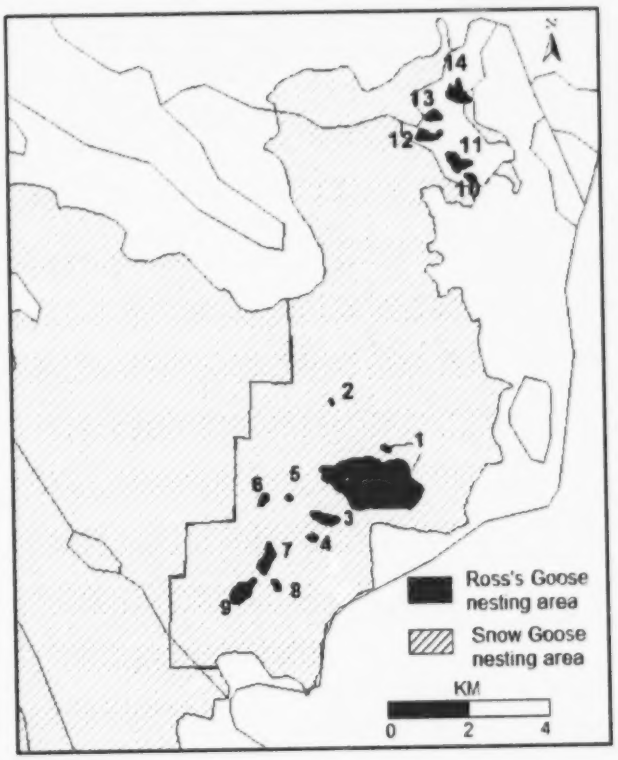

Figure 25
Ross's Goose nesting areas at McConnell River, Nunavut, June 1997. (Black = 100mX100m grid squares with more than 20 nesting white birds – see text and Fig. 20)

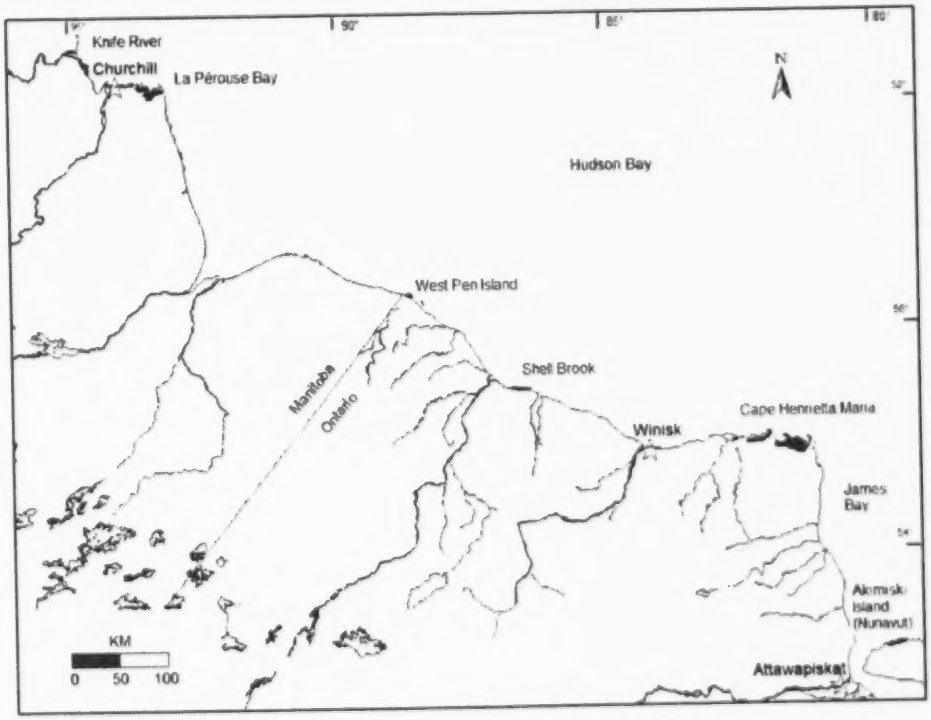

Figure 26
South Hudson Bay Lesser Snow Goose colonies, June, 1997

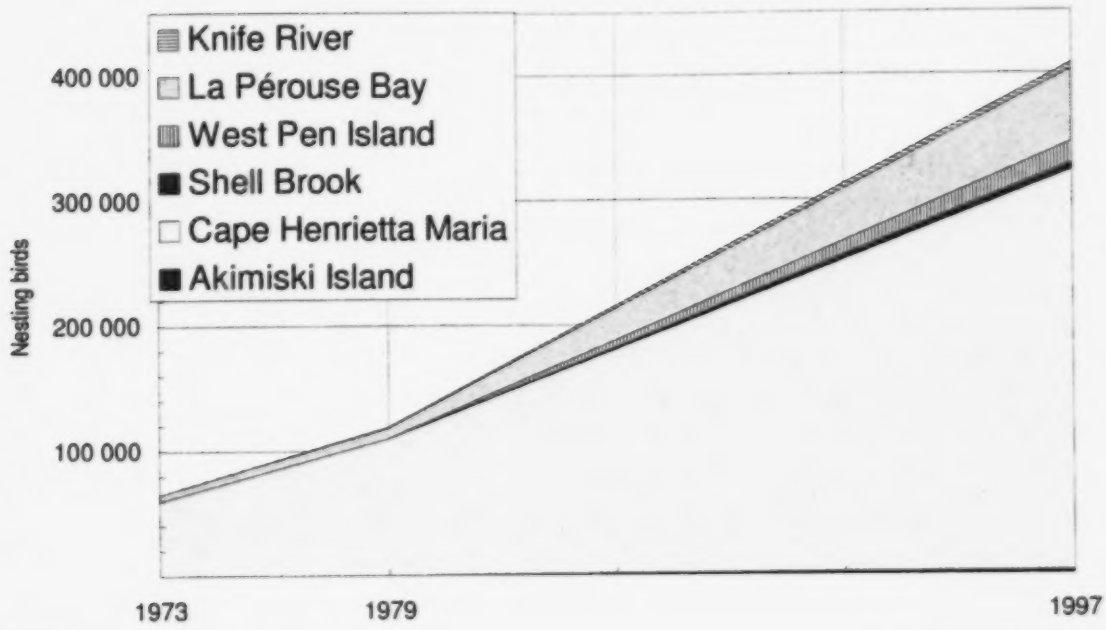

Figure 27
Growth in numbers of nesting birds by colony of Lesser Snow Geese, South Hudson Bay, 1973-1997

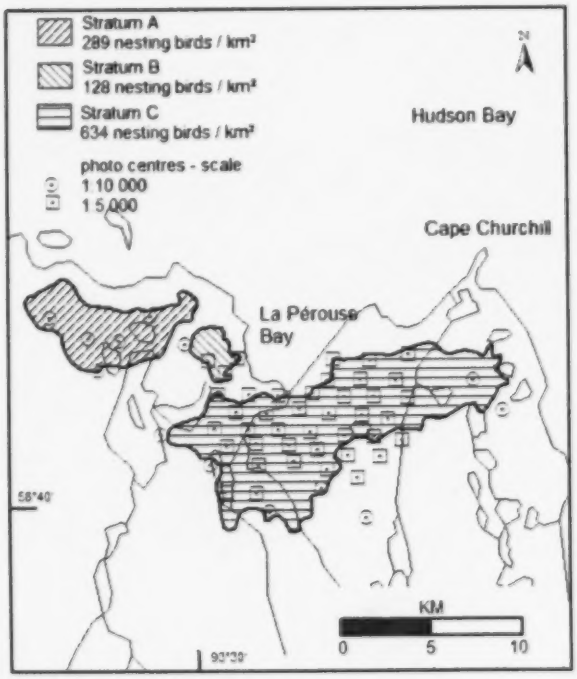

Figure 28
Lesser Snow Goose colony at La Pérouse Bay, Manitoba, showing the area occupied by nests, June, 1997

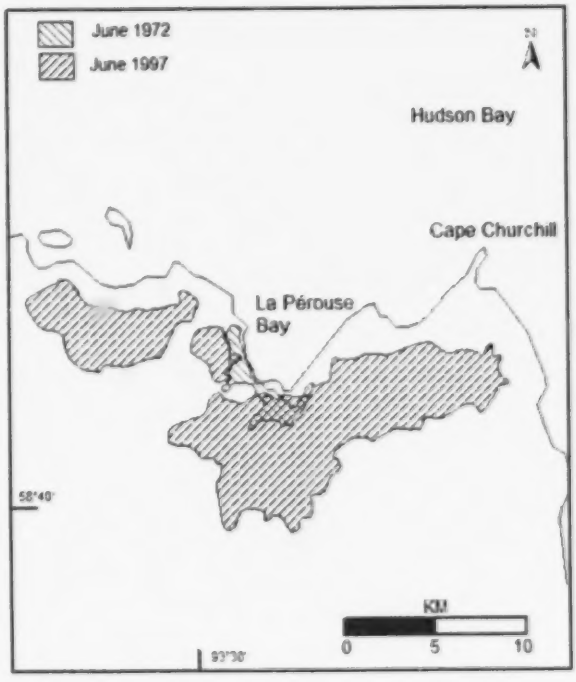

Figure 29
La Pérouse Bay Lesser Snow Goose colony, showing the area occupied by nests in June, 1972 and June, 1997

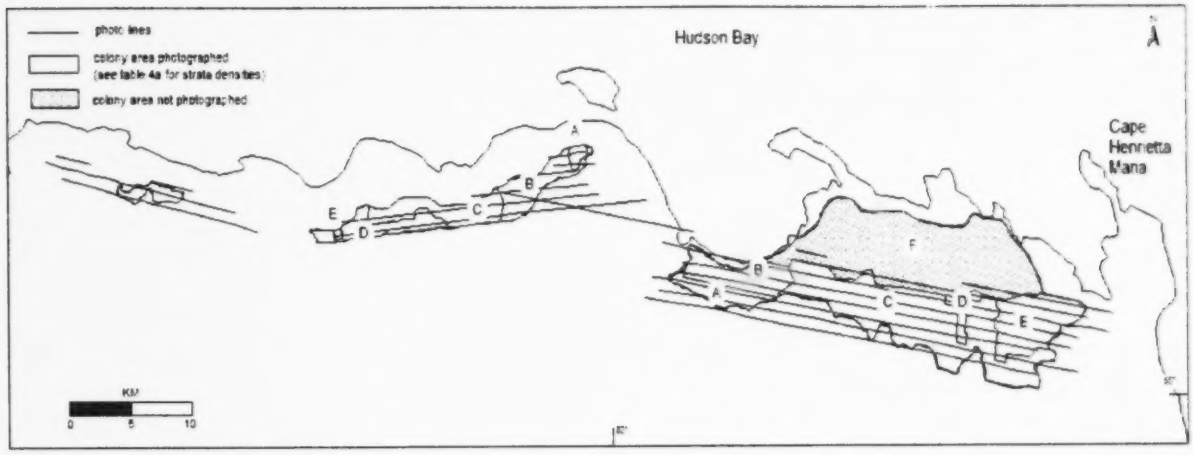

Figure 30
Lesser Snow Goose colony at Cape Henrietta Maria, Ontario, showing the area occupied by nests, June, 1997

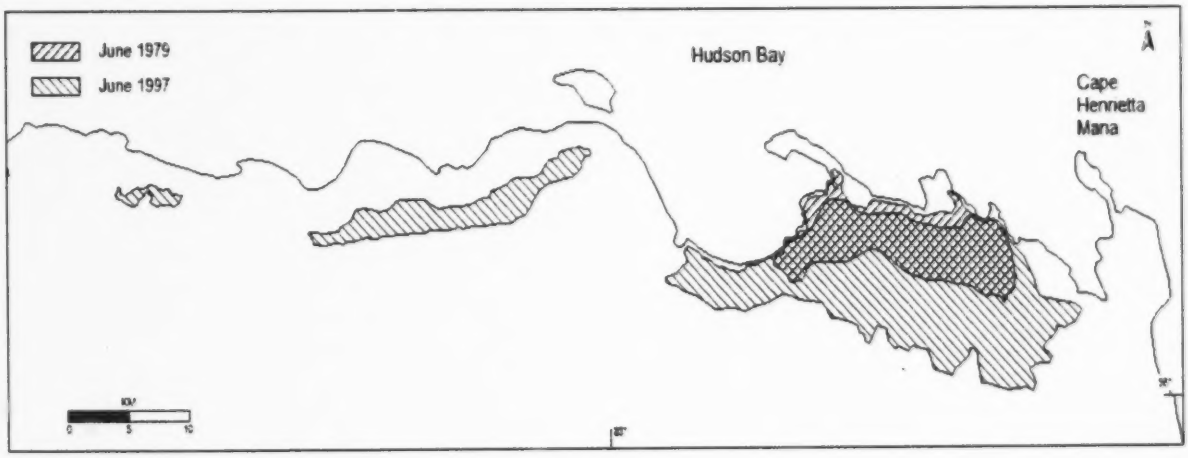

Figure 31
Lesser Snow Goose colony at Cape Henrietta Maria, Ontario, showing the area occupied by nests in June, 1979, with expansion recorded in 1997.

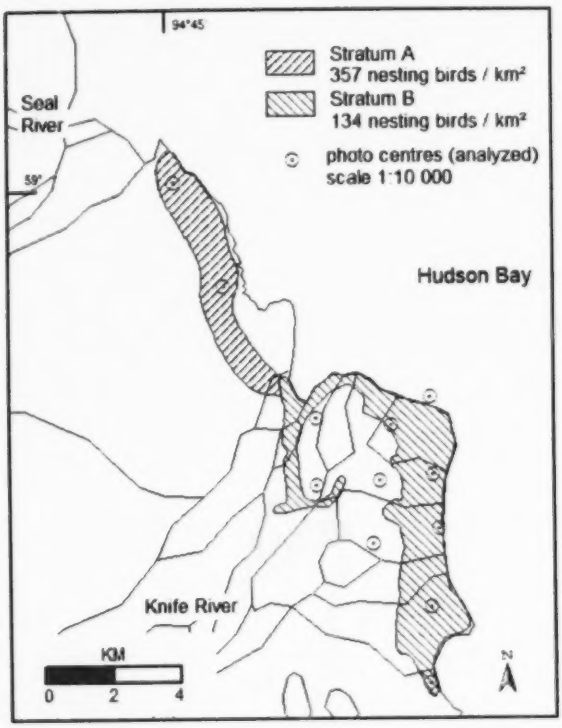

Figure 32
Lesser Snow Goose colony at Knife River, Manitoba, showing the area occupied by nests, June, 1997

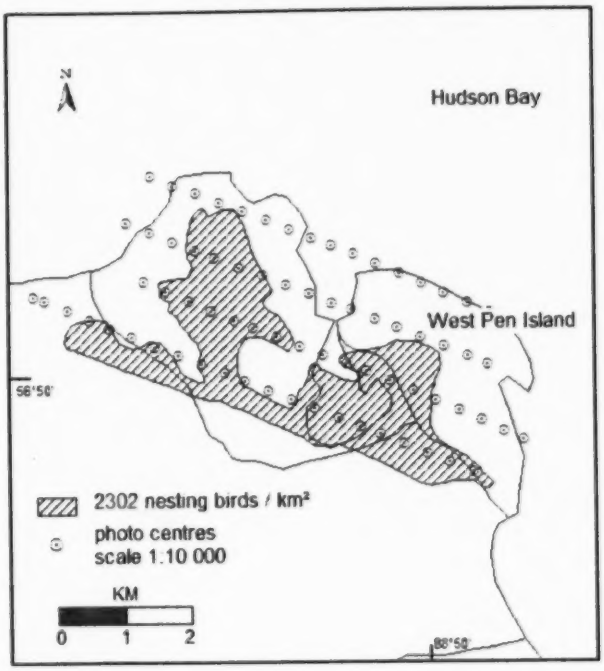

Figure 33
Lesser Snow Goose colony at West Pen Island, Ontario, showing area occupied by nests, June, 1997

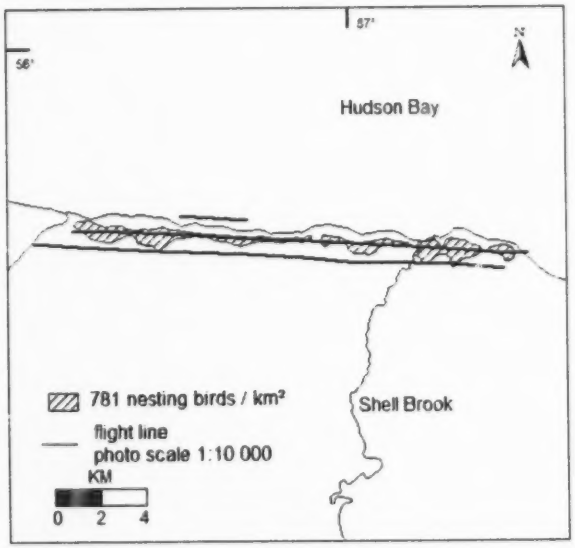

Figure 34
Lesser Snow Goose colony at Shell Brook, Ontario, showing area occupied by nests, June, 1997

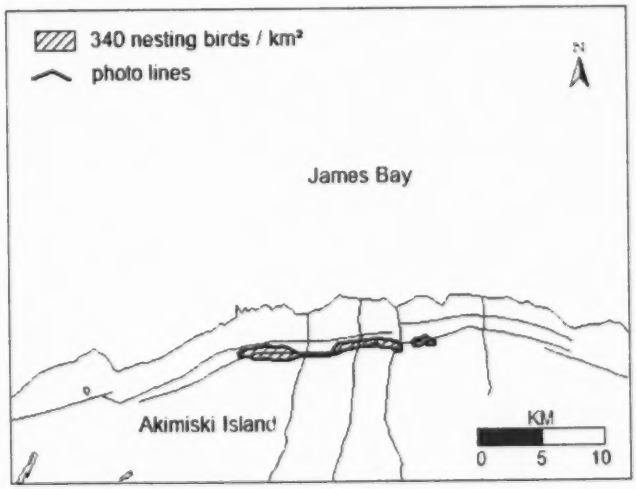

Figure 35
Lesser Snow Goose colony at Akimiski Island, Nunavut, showing the area occupied by nests, June, 1995

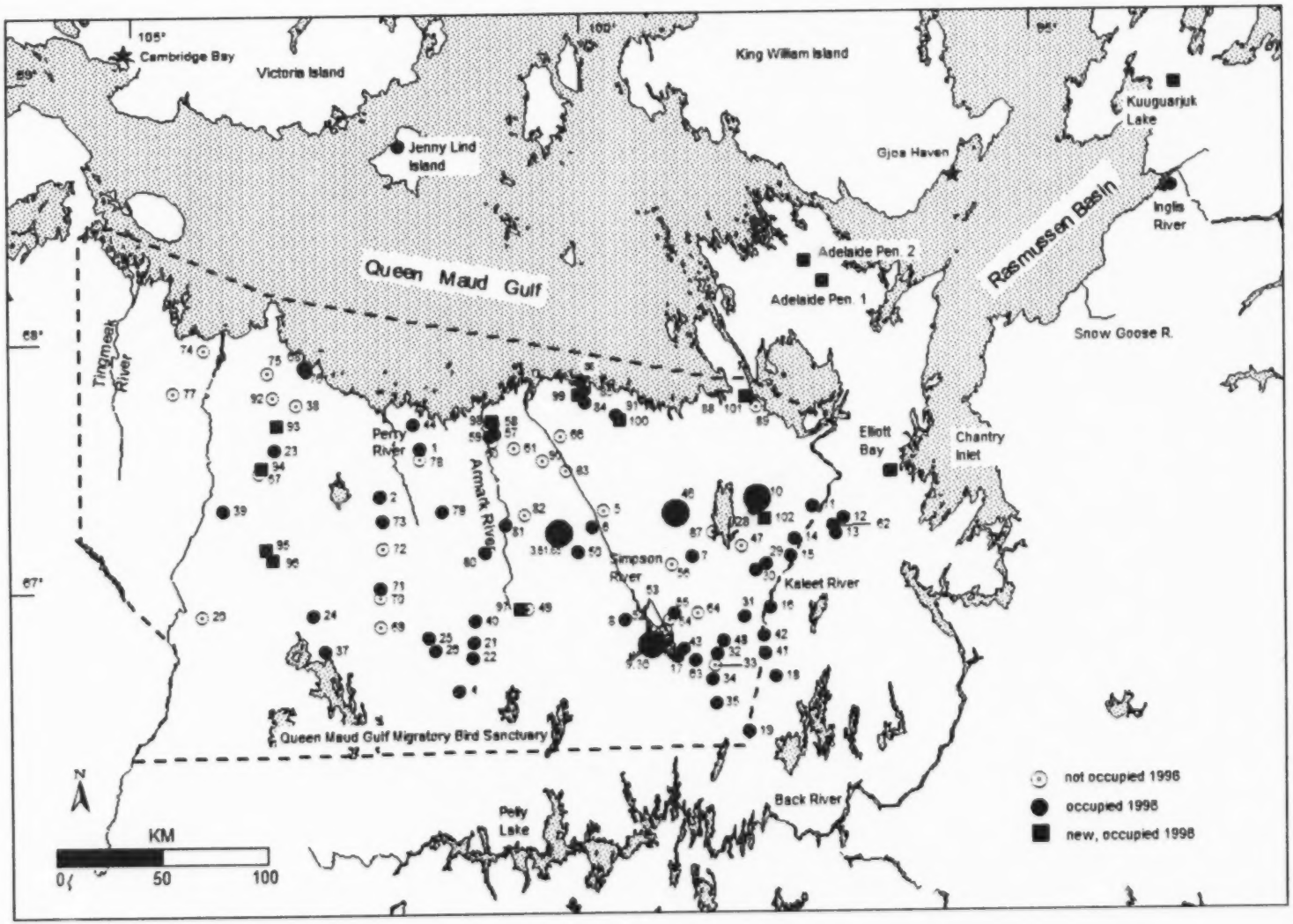

Figure 36
Lesser Snow and Ross's goose colonies in the Central Canadian Arctic, Nunavut, 1965-1998

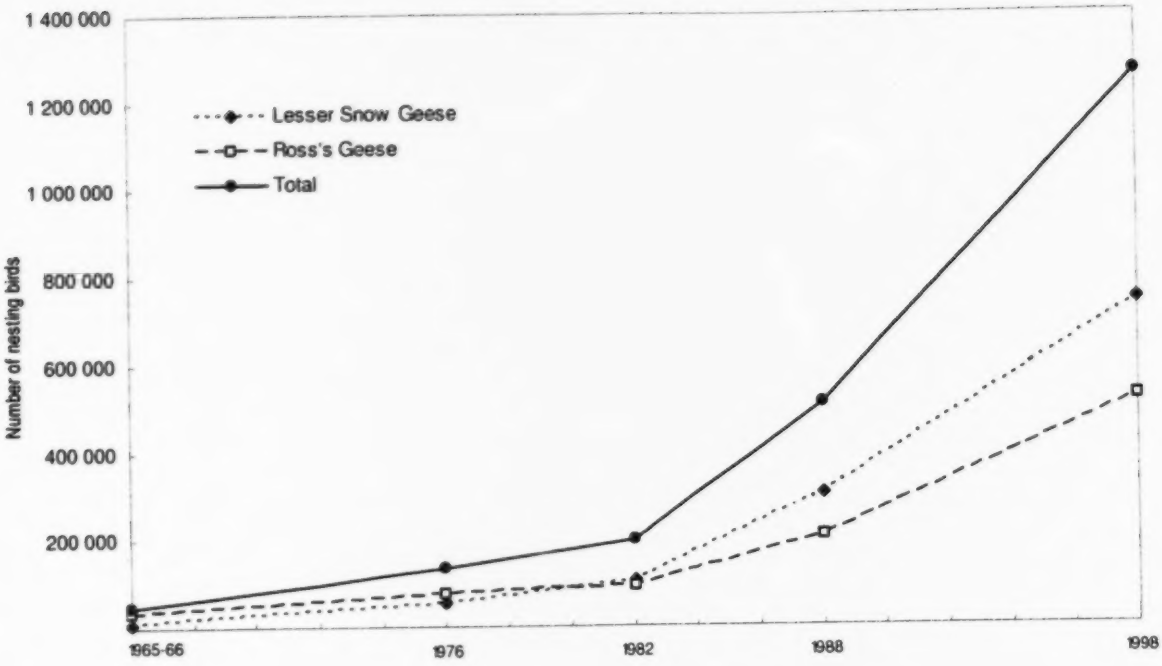

Figure 37
Growth in numbers of nesting Ross's Geese and Lesser Snow Geese, Central Canadian Arctic, 1965-1998
Note: 1988 includes Jenny Lind Island and 1998 includes Jenny Lind Island, Adelaide Peninsula, Elliott Bay, Inglis River and Kuuguarjuk Lake

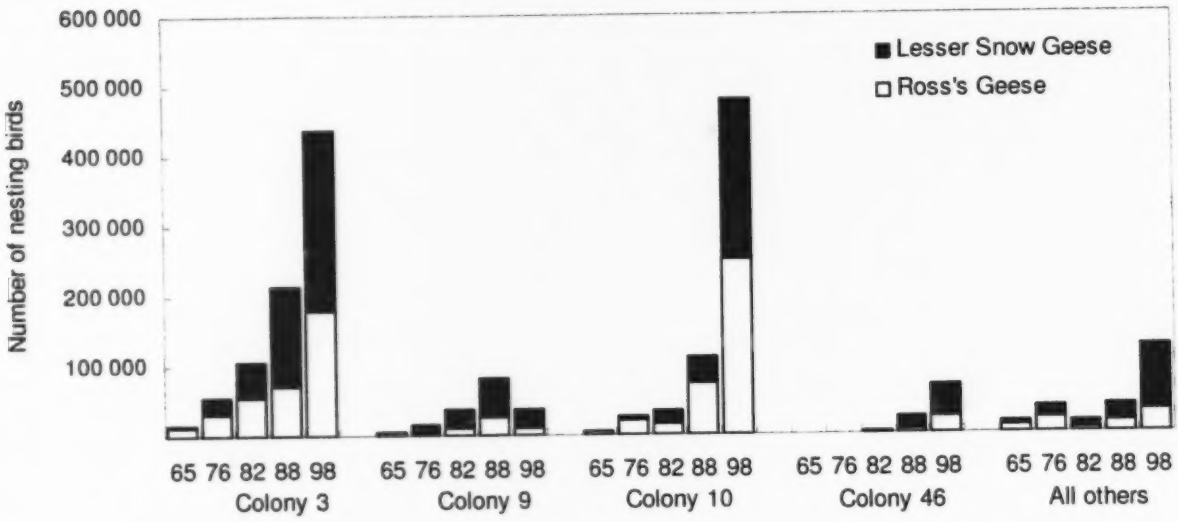

Figure 38
Numbers of Ross's Geese and Lesser Snow Geese nesting in colonies 3, 9, 10, and 46, compared with all other colonies combined in the Queen Maud Gulf Migratory Bird Sanctuary area, 1965, 1976, 1982, 1988 and 1998

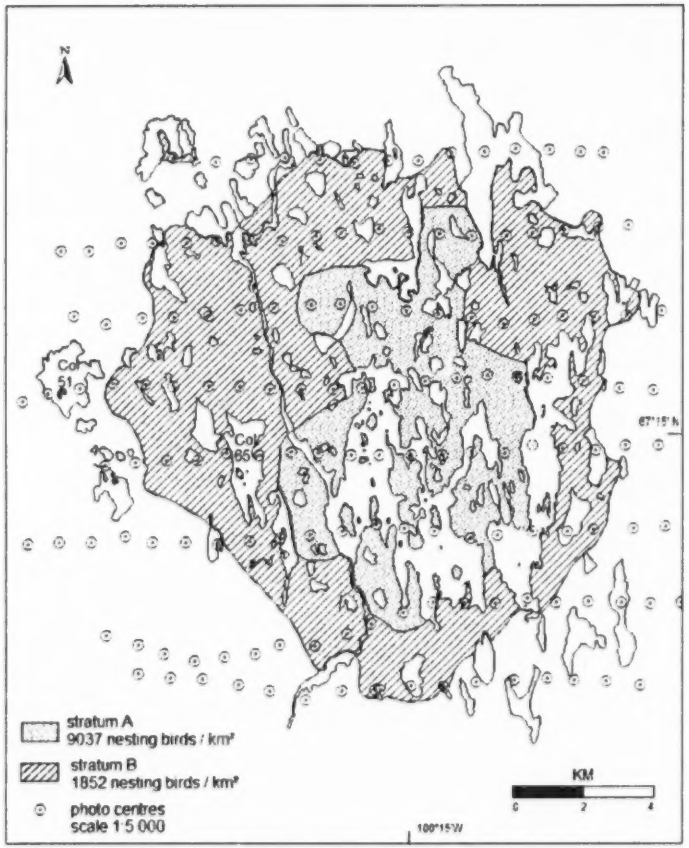

Figure 39
Colony 3 (Karrak Lake) including colonies 51 and 65, showing the area occupied by nesting Lesser Snow and Ross's geese, June, 1998

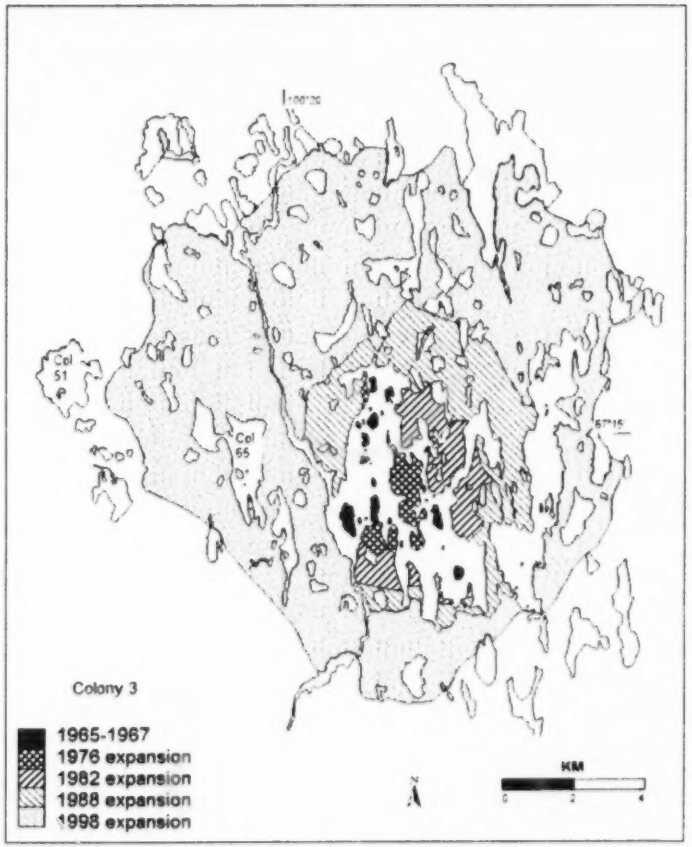

Figure 40
Colonies 3 (Karrak Lake), 51 and 65, showing area occupied by nesting Ross's and Lesser Snow geese, 1965-67, with expansion recorded in 1976, 1982, 1988 and 1998

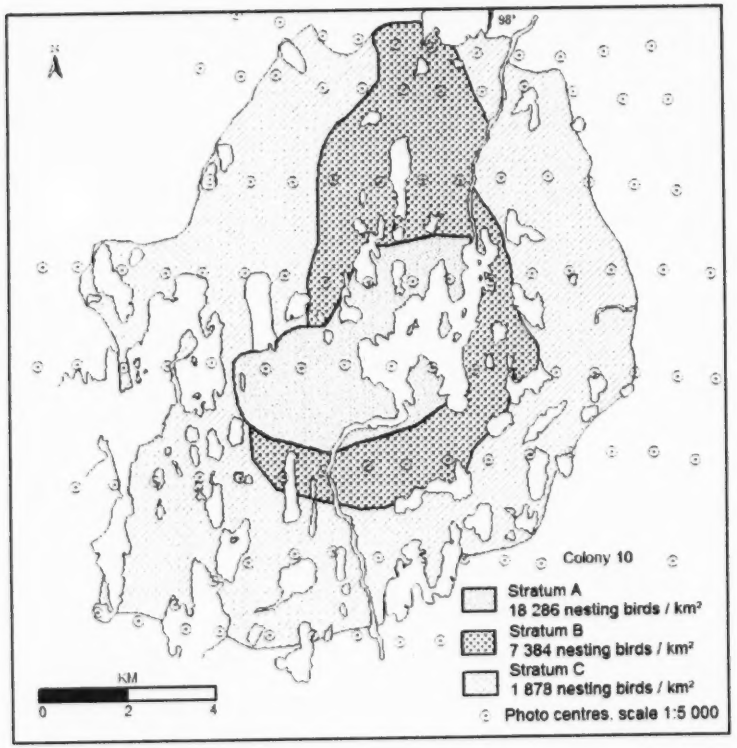

Figure 41
Colony 10, showing the area occupied by nesting Ross's Geese and Lesser Snow Geese, June, 1998

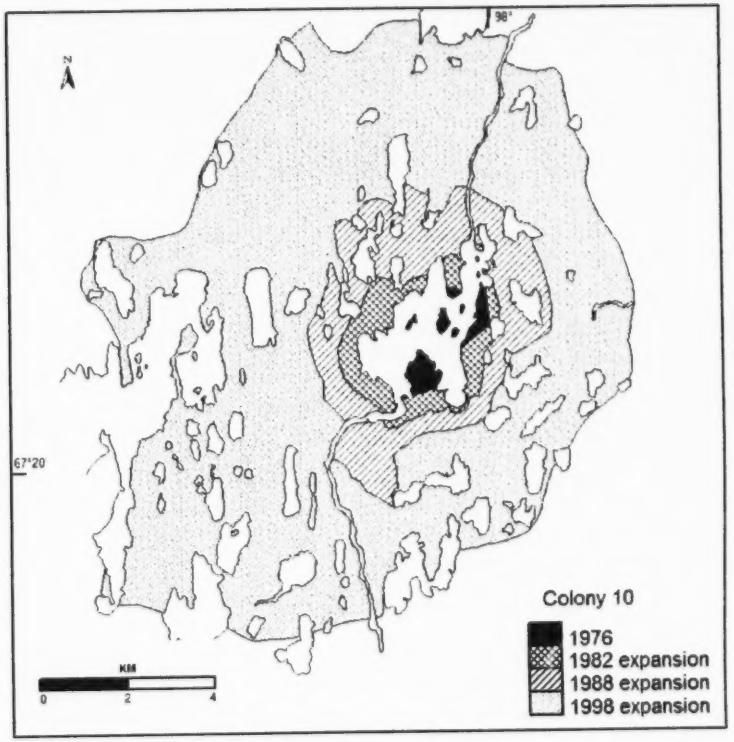

Figure 42
Colony 10, showing area occupied by nesting Ross's and Lesser Snow geese in 1976, with expansion recorded in 1982, 1988 and 1998

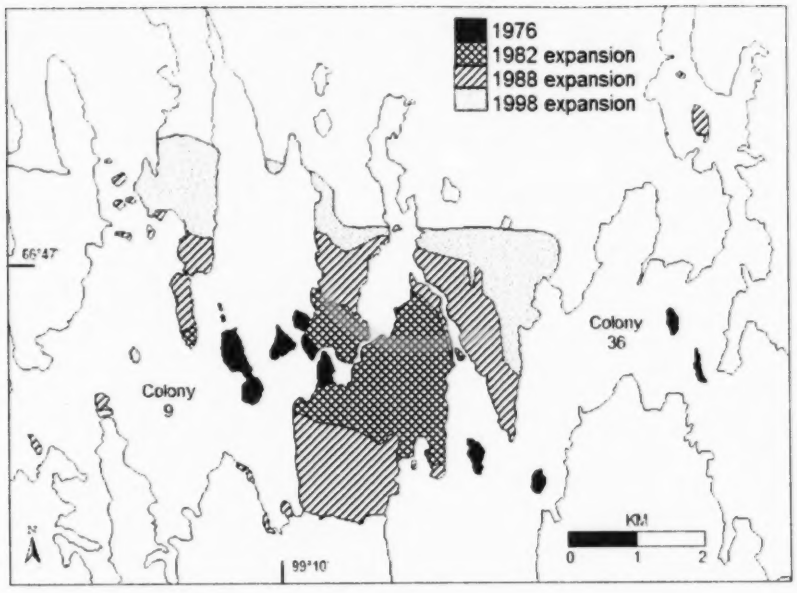

Figure 43
Colonies 9 and 36, showing area occupied by nesting Ross's and Lesser Snow geese in 1976, with expansion recorded in 1982, 1988 and 1998

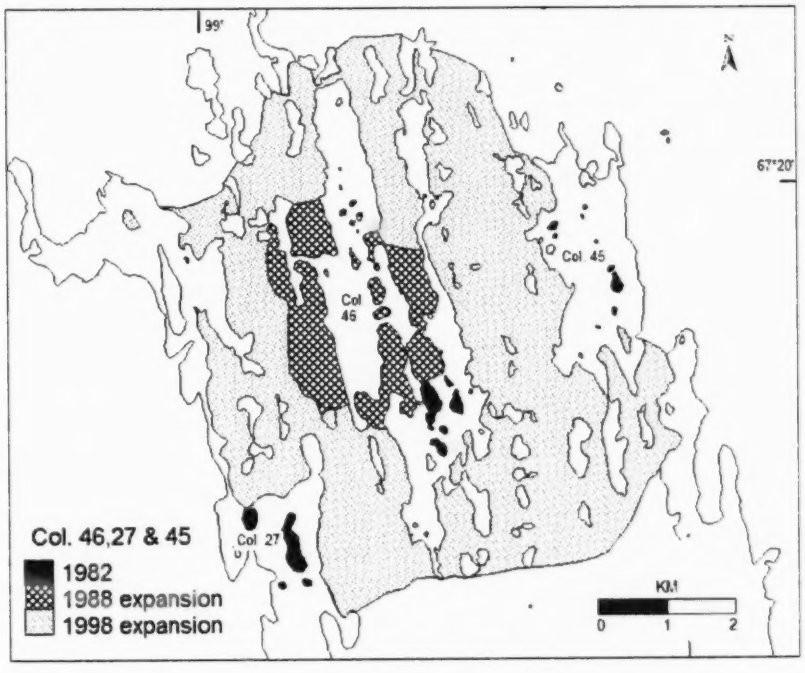

Figure 44
Colonies 46, 27 and 45, showing area occupied by nesting Ross's and Lesser Snow geese in 1982, with expansion recorded in 1988 and 1998

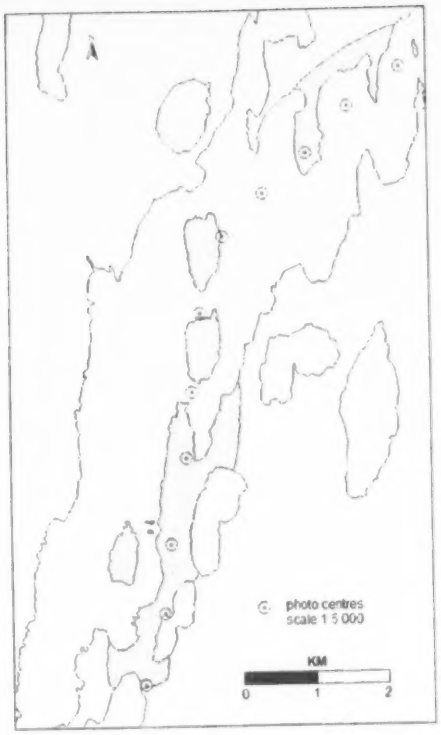

Figure 45
Elliott Bay colony, showing area occupied by nesting Ross's Geese and Lesser Snow Geese, in June 1998

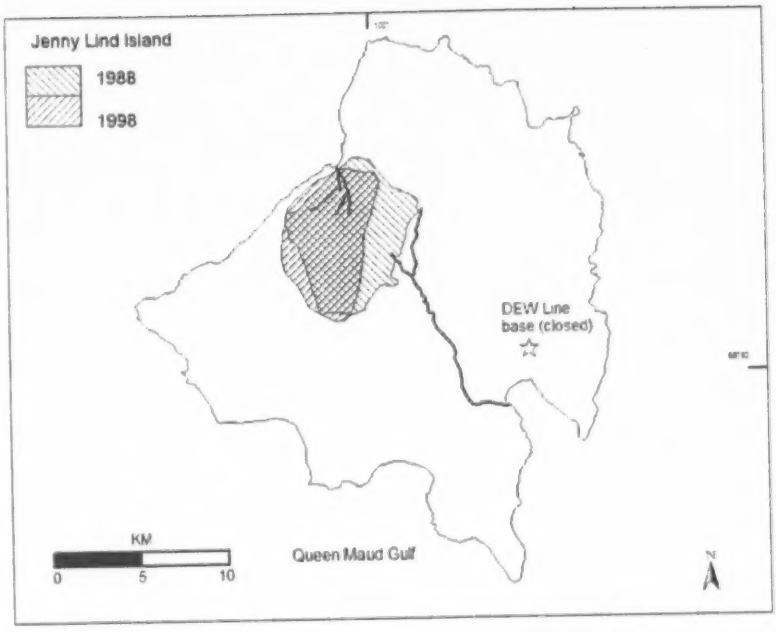

Figure 46
Colony at Jenny Lind Island, showing area occupied by nesting Lesser Snow and Ross's geese in June, 1988 and 1998

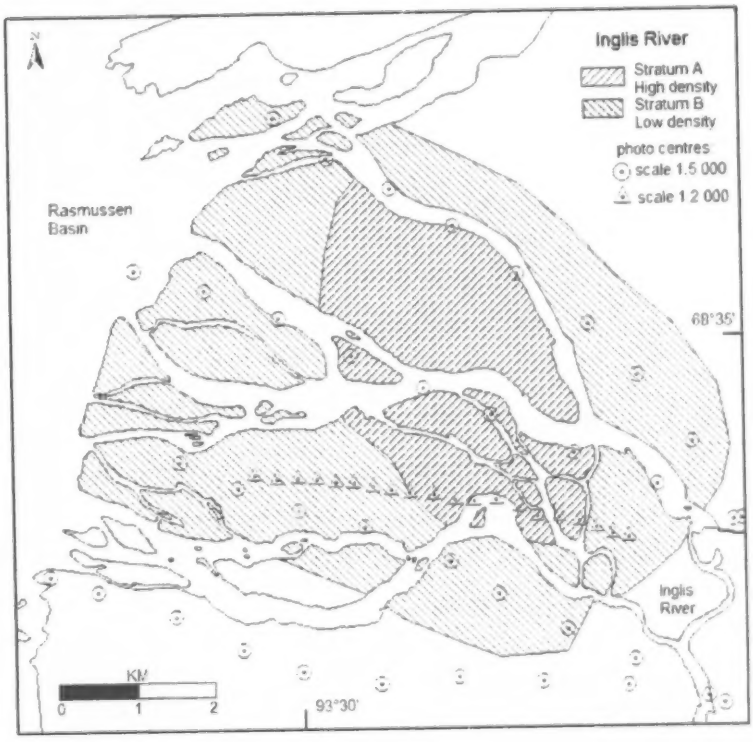

Figure 47
Inglis River Lesser Snow Goose nesting area, showing area occupied by nests in June, 1998

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